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THE PASSAIC VALLEY TRUNK SEWER BILL was reenacted by the New Jersey legislature on April 21 by a special session of the legislature. This course was made necessary by an omission in the bill signed by the governor of an amendment providing that work on the sewer should not be started until the governor and attorney-general were satisfied that there was no danger of interference by the State of New York on account of the discharge of sewage into New York Bay.

A WATER FILTRATION PLANT FOR CLEVELAND, O., has been recommended by the council committee on health, but Director of Public Works Salen and Engineer Williams advise that such action be postponed until the new tunnel is in use and the character of the water from the new lake intake has been ascertained.

THE PROPOSED MUNICIPAL STREET LIGHTING plant for New York will have to be postponed, owing to the failure of the enabling act in the state legislature.

THE NEW YORK WATER STORAGE or flood prevention bill failed to pass the state legislature. In general, it provided for carrying out the measures recommended by the water storage commission of 1902, whose report was abstracted in our issue of Jan. 29, 1903.

THE PUBLIC WATER SUPPLIES OF VERMONT, particularly those derived from deep wells and from springs, are to be investigated by Prof. Geo. H. Perkins, of the University of Vermont, Burlington, Vt., in behalf of the U. S. Geological Survey, and in connection with Professor Perkins' work as State Geologist.

RAPID FIELD ANALYSES OF WATER may be made under a system perfected by the officers of the Hydrographic Division of the United States Geological Survey, the object being to make a number of approximate determinations, sufficiently accurate for practical purposes, rather than a few very complete determinations. A special equipment has been designed which will be issued shortly, and can be carried without inconvenience by the men engaged in the field work of investigating quality of water. The railway companies and railway chemists are interested in the matter, as by the new system as many as 60 determinations of sulphate in water can be made in one day, thus greatly facilitating the work of investigating the quality of boiler waters.

STATE AID FOR ROAD IMPROVEMENT has been adopted in Pennsylvania, and the State has appropriated $6,500,000 to be expended for this purpose. The plan is that on each piece of work the State will pay 66% of the expense, while the county and township in which the work is located will each pay 17% of the cost.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a rear collision which occurred on the Missouri Pacific Ry., near Buffalo, Kan., on April 26. A work train filled with laborers was run into by a stock train, and was almost completely destroyed. Most of the men were on flat cars and escaped by jumping, but those in the caboose were killed or seriously hurt. Eleven men were killed outright in the wreck.

AN EXPLOSION OF OIL TANKS at the plant of the Northwestern Star Oil Co., Minneapolis, Minn., on April 23, killed eight men and two women, besides destroying $55,000 worth of property. The entire office force of the company was killed, including the president, Mr. W. H. Davis, and the general manager, Mr. C. H. Durrin. The cause of the explosion has not been determined, but it is said that employes of the company were emptying some oil-tank cars into the tanks in the basement of the building, and it is possible that sparks from a switch engine ignited the oil.

THE LOUVRE ROOF COLLAPSED on the new mechanical engineering building at Stanford University, causing $1,200 damage.

THE FAILURE OF A CONCRETE FLOOR at Milwaukee, described in our issue of April 9, has been investigated by Mr. W. D. Taylor, M. Am. Soc. C. E., Professor of Railway Engineering at the University of Wisconsin, who wrote the following letter to Mr. W. S. Johnson, President of the Johnson Service Co., the owner of the building:

> In reply to your letter of April 8, asking for a report of the tests made on April 4 on your building now in course of construction at the corner of Michigan and Jefferson Sts., I will state: I caused to be placed upon some of the floor beams a weight of load sufficient to induce strains in the floor construction of two or three times greater than those that would be induced by the maximum working load of 160 lbs. per sq. ft., for which the building is designed. The result of these tests was entirely satisfactory. These floors could not have stood this test had the concrete of which they are constructed been adversely affected by temperature conditions during the winter.

RAILWAY ACCIDENTS for the quarter ending Dec. 31, 1902, are summarized by the Interstate Commerce Commission. During the quarter 266 persons were killed, and 2,788 injured in train accidents, and property damage was caused amounting to $2,462,056. The total casualties of every sort to passengers, employees and others in the quarter amounted to 938 persons killed, and 11,873 injured. The total number of collisions was 1,683, and derailments 1,079, of which 232 collisions and 99 derailments affected passenger trains.

TWENTY LOCOMOTIVES have been ordered from a German locomotive builder, the R. Hartmann Co., in Chemnitz, by the Canadian Pacific Ry. This is said to be the first time that an American railway has bought locomotives in Germany. They are to be two-cylinder compounds, for passenger service, with three pairs of drivers and a four-wheel leading truck. The loaded weight of the engine is 84 tons, the loaded weight of the tender 63 tons, or the total weight of engine and tender 147 tons.

TWO NEW ARMORED CRUISERS were launched during the past two weeks. On April 18 the "West Virginia" was launched at the yard of the Newport News Shipbuilding & Dry Dock Co., at Newport News, Va., and just a week later the "Colorado" slid down the ways at the yard of the Cramp Shipbuilding Co., at Philadelphia, Pa. The former vessel has dimensions of 502 ft. length on load water line, 59½ ft. extreme breadth, and 24 ft. draft at normal displacement. The full-load displacement is something over 15,000 tons; the "West Virginia" has engines of 23,000 I. HP., and is intended to have a speed of 22 knots. The two triple-expansion vertical engines run at 120 r. p. m. and take steam at 250 lbs. pressure from 16 B. & W. marine boilers. The main battery comprises four 8-in. rifles, and fourteen 6-in. rifles, ten of the latter being mounted on the gun deck, the other eight rifles in turrets. The armor belt is of 6-in. plate, while the turret armor is 6 and 6½ ins. thick. The "Colorado" is a sister ship to the "West Virginia" in all but minor details, so that the preceding data apply also to her.

THE TOLLS ON THE ST. LAWRENCE CANALS have been removed by the Canadian Government and a large increase in shipments of export grain via Montreal is expected. The tolls have been 3-ct. per bushel, and the total income to the Treasury has been about $240,000 per annum.

THE SYNDICATE which subscribed $200,000,000 to underwrite the securities of the United States Steel Corporation at its organization, has finally been dissolved. Only $25,000,000 of the original amount called for was paid in by the members of the syndicate, and this was repaid to them in a short time. Since then profits of nearly $50,000,000 have been divided among the subscribers.

THE EL PASO DRAINAGE TUNNEL, at Cripple Creek, Colo., has been enjoined by the Cripple Creek Tunnel, Transportation & Mining Co., through whose property the "El Paso Tunnel" seeks to go. The company just mentioned owns the "Standard Tunnel," which will be rendered valueless if the "El Paso Tunnel," 150 ft. lower down, is built; and vigorous effort will be made to stop the building of the rival.

DREDGING A VINEYARD FOR GOLD is to be begun at Natoma, California, according to local newspaper reports. The Folsom Development Co. will take the place of the Natoma Vineyard Co., thus reversing the usual order of mining and agricultural development.

SMOKE PREVENTION AT CHICAGO is provided for by a city ordinance passed on March 23 by a vote of 47 to 15, "creating a Department for the Inspection of Steam Boilers and Steam Plants." This department will have as its head a chief inspector, besides whom there will be a supervising mechanical engineer and chief deputy inspector, and a chief smoke inspector. The three officials named will constitute a board of inspectors of steam boilers and steam plants. The board will inspect and test all steam boilers and steam plants in the city, including those of the city itself and its board of education, and no new plants shall be built, nor old ones reconstructed, nor any new chimney connected with a steam plant shall be built until the plans and specifications have been filed with and approved by the board of inspectors. In the matter of smoke prevention, the ordinance declares the "emission of dense smoke from the smokestack of any boat or locomotive, or from any chimney anywhere within the city" a public nuisance, and provides penalties therefor. Three minutes of dense smoke at one time, or six minutes when a firebox is being cleaned or a new fire built, is allowed. Provision is made for prosecuting offenders, but before any such prosecution three separate notices, within ten days of beginning the prosecution, must be mailed to the offender, stating that "dense smoke has been seen emitted from his premises." Owners of all old plants are exempt from prosecution for one year from the passage of the ordinance, to give time to rebuild or re-equip plants, but the year's time will be forfeited by any owner who fails to begin the changes at once, and prosecute them to the satisfaction of the board. Finally, a section of the ordinance may be quoted as follows:

> It shall be the duty of the board to see that the boiler or boilers, boiler setting, means of producing draft, smoke connections, and furnace or firebox of each boiler inspected by it are of sufficient capacity and so constructed as with proper management to avoid the emission of dense smooke.

COAST SURVEY WORK IN THE PHILIPPINES has been carried on for two seasons past, and is being steadily extended. There are at present some six or seven parties in the field; two of these are hydrographic parties making harbor and coast surveys, using the survey steamer "Pathfinder," which had been previously engaged in similar work in Alaskan waters, and the steamer "Research," furnished the survey by the Insular Government. Three astronomical parties have been at work, and about 50 astronomical stations have been established and their positions determined. A system of triangulation, which has already been commenced, will be carried between these stations. The entire work is done by the U. S. Coast and Geodetic Survey, though the Insular Government has aided the work with money and men. The work is described in a recent issue of the Manila "Daily Bulletin" by Mr. G. R. Putnam, Assistant, U. S. Coast and Geodetic Survey. The statement that the coast line of the Archipelago (11,444 statute miles) is more than double the length of the combined Atlantic, Pacific and Gulf coasts of the United States, will indicate the extent and importance of the work to be done. The Customs Service has already designated over 160 places as ports and subports.

THE AGRICULTURAL POSSIBILITIES OF ALASKA are pointed out by Mr. F. T. Condon, the new Canadian Yukon Commissioner, who states that when the moss is removed from the soil that it is found to be very fertile. He is reported as saying: "I want to impress upon the public mind that the future of the Yukon does not depend upon minerals of any kind. The district is destined to be one of the greatest agricultural spots in the world."

THE NEW 30-IN. HYDRAULIC DREDGE FOR THE PORT OF PORTLAND, OREGON.

(With two-page plate.)

One of the most noteworthy hydraulic dredges ever built has recently been constructed and put in operation at Portland, Oregon. This dredge was built for the Port of Portland Commission and is to be employed for general dredging operations in Portland Harbor. It is a suction dredge pump, the exception being machines operated by the vacuum process.

In the vacuum system practically two dredges are required to do the work of one, and the expense of operation is so great in proportion to the output as to place them out of consideration. Self-propelling dredges it is not necessary to report upon, since the material can be deposited within 1,000 ft. of the cut and since the distance from bar to bar is short. This leaves for consideration

FIG. 3. END VIEW OF STEEL TRUSSES FOR PO RT OF PORTLAND DREDGE.

FIG. 6. VIEW SHOWING STEEL LADDER FOR PORT OF PORTLAND DREDGE.

of the form familiar to engineers, in which the material to be dredged is loosened by a rotating cutter; drawn through the suction pipe by a centrifugal pump, and delivered ashore by means of a long discharge pipe carried on floats. While, therefore, the new dredge does not vary materially from others of the same type in its general form, an attempt has been made to improve upon previous machines by superior excellence of detail and workmanship, particularly with respect to the operating machinery.

PRELIMINARY STUDIES.

The design and construction of the new dredge was placed in the charge of Mr. J. B. C. Lockwood, M. Am. Soc. C. E., Consulting Engineer for the Port of Portland Commission. In preparation for his work Mr. Lockwood made a careful study of the various large dredges previously built in the United States, visiting personally all those with whose construction he was not already familiar. The information developed by this study and the conclusions to which it led as related to the proposed work of the Port of Portland may be summarized briefly as follows:

The work of a hydraulic dredge comprises three operations: (1) Getting the machine to the material to be excavated; (2) displacing or excavating the material; and (3) disposing of the excavated material. The operation of moving ahead to the work is performed in the following ways: (1) Pulling ahead by one or more lines fastened to anchors while holding the suction pipe at a given depth; (2) pulling ahead by means of one or more lines fastened to anchors, then lowering the suction pipe into the material to be excavated; (3) pulling ahead by means of one or more lines fastened to anchors, then dropping a spud and swinging the dredge from side to side; (4) pulling ahead by means of one or more lines fastened to anchors, dropping more than one spud and swinging part of the dredge or only the cutting apparatus; (5) moving ahead by means of one working and one walking spud, both placed in the center line of the dredge, one of which can be moved vertically and the other both horizontally and vertically; (6) self-propelling dredges moving ahead under their own steam. The second operation, that of loosening the material to be excavated, is performed by rotary cutters, by water jets, by the erosive action of the water flowing into the suction pipe, and, in vacuum dredges, by a separate dipper dredge dumping into a hopper at the front of the hull. The third operation, that of discharging the excavated material, is performed in all cases except one by a centrifugal only centrifugal pump dredges using some form of excavator and discharging the material through a pipe line and moving or setting up on the work either by lines, by spuds, or by a combination of the two.

As differences in pipe lines, discharge, and the centrifugal pump can only be in matters of detail, the principal difference in machines of the type considered lie in the arrangements for moving ahead and in the devices for excavating the material. A logical deduction would seem to be, therefore, that a dredge with the best means of moving about and with the best excavating apparatus would of necessity be the best machine. While this conclusion is generally true, it is not necessarily so, and it is especially not so where the material is easily displaced or if the pipe line is very long.

The simplest method of moving a dredge forward on its work is by pulling straight ahead by means of lines fastened to anchors. This is the universal method used on the dredges of the Mississippi River Commission. It is most practical under this method to pull up-stream, and the cut made is necessarily narrow, being limited in its bottom width to the width of the suction pipe, and the distance from which the material will flow to the pipe under the influence of the stream of water flowing to it, ordinarily from 10 ft. to 20 ft. The narrower the cut which a dredge will make, the greater proportion, of course, is the part of the time which is lost in moving. When working in hard material it is necessary to loosen it a little at a time and the proportion of lost time increases as the material becomes harder to displace. The combined system of lines and spuds for moving ahead is at best complicated and for this reason, if for no other, it should be avoided. Respecting the method of moving ahead by walking spuds there are four objections: (1) It is complicated; (2) the cost of installation is large; (3) it requires the use of square spuds; and (4) it requires an extra man to operate it. Another system in quite extended use is where spuds are placed on line athwartship, and the dredge is moved ahead by swinging first on one spud and then on the other. It is the simplest system of any, except the straight head feed, and where a wide channel is to be excavated it is the best system in use. The method of swinging only the excavating apparatus on a hinge at the front of the dredge is to be recommended for use only where there is not sufficient space for swinging the whole machine, or where the cut to be made is quite narrow.

The excavating apparatus of centrifugal dredges are either water jets or rotary cutters. The water jet dredges of the Mississippi River Commission work with very poor success as compared with those having rotary cutters, unless the material to be excavated is very soft. There is, however, a great difference in rotary cutters, and of those on the dredges visited not one had power enough to do its work properly. Most of the main pumps used had volute casings with open runners. The lately designed pumps are lined and some have shrouded or closed runners. In main engines the general practice is tending toward the vertical triple-expansion, direct-connected type, except on the Mississippi River, where horizontal tandem compound engines are favored. In boilers no particular type is favored, Scotch marine, tubular and water-tube types all being used. In general neither in design, efficiency or in the quality of workmanship of the machinery used does the practice in dredging approach that of the best marine or stationary practice. This is the more remarkable as there is almost no place where

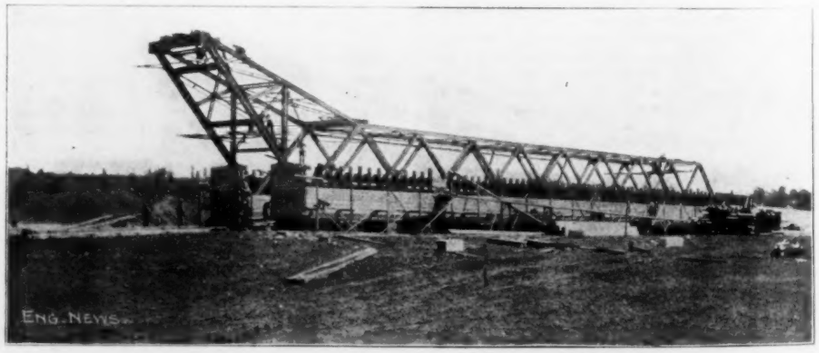

FIG. 5. VIEW OF HULL DURING CONSTRUCTION SHOWING STEEL STRUCTURE IN PLACE.

good design and first-class workmanship is more necessary on account of the severe strains and the great changes in load to which such machines are subject.

Basing his action on the information and conclusions which we have briefly summarized, Mr. Lockwood recommended a 24-in. centrifugal machine, with two spuds for setting ahead, a rotary cutter operated by compound engines, a centrifugal pump with shrouded runner operated by a

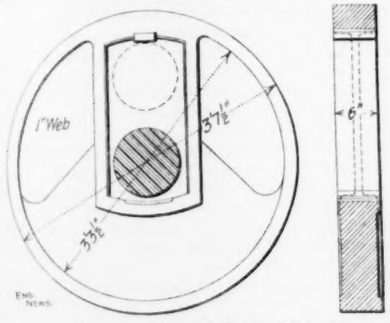

Fig. 9. Detail of Counterbalance Disk for Crank Shaft of Main Engine.

vertical triple expansion direct-connected engine and water-tube boiler. Except that a 30-in. pump was used, these recommendations were substantially followed in the dredge which was built and a general plan and longitudinal section of which are shown by Fig. 1.

CONSTRUCTION OF HULL AND ACCESSORIES.

The hull of the new Port of Portland dredge is of timber braced by steel trusses, and included with it as integral parts or accessories are the house, machinery foundations, spuds and spud fittings, and the suction pipe ladder. The general arrangement of these several parts is shown by the drawings of Fig. 1, and their construction is described in more detail as follows:

HULL.—In outside dimensions the hull is 225 ft. 9 ins. long, 42 ft. wide, and 11 ft. 8¼ ins. deep. It is constructed throughout of Oregon pine timber. Fig. 2 shows sections at various points lengthwise and across the hull. These sections may be co-ordinated with the outline sectional elevation of Fig. 1 by means of the subscriptions In general it will be observed that the bottom of the hull is made up of 20 keelsons, to which the bottom planking is spiked and which carry on top transverse floor beams. Rising from the corner keelsons are stanchions and corner posts to which the side planking is spiked. The deck framing is clearly shown by the drawings. The hull is crossed transversely by solid timber bulkheads at points just aft of the ladder well and of the engine room. A solid timber wall of similar construction forms each longitudinal side of the ladder well, which is 11 ft. wide and 38 ft. 3 ins. long.

STEEL STRUCTURE.—Vertical stiffness is given to the hull by two longitudinal trusses spaced 18 ft. apart. These trusses are each 215 ft. long and 21½ ft. deep. Their arrangement and form are shown by Fig. 1 and Fig. 3. The bottom chords are parallel 12-in. 30-lb. channels connected by bottom lacing, and also by the bottom plates of the floor beam hangers (Fig. 4); the top chords and end posts are parallel 12-in. 20-lb. channels, with top and bottom lacing; the diagonals consist of four 6 × 3½ × ⅝-in. angles, laced with 2½ × ⅜-in. straps and with 12 × ⅝-in. bottom plates at the ends; and the transverse struts between top chords are of the same composition as the diagonals. These trusses are connected to the hull structure by being suspended from the transverse floor beams under which the bottom chords pass, and are attached as shown by the drawing, Fig. 4. These connections are spaced from 5 ft. to 5½ ft. apart, according to the spacing of the floor beams.

The steel truss structure is terminated at its forward end by a cantilever frame, which overhangs the ladder well and serves as a support for the ladder hoisting mechanism. This frame is formed of two parallel cantilever trusses connected by transverse struts and lateral X-bracing in the planes of the top and bottom chords and by a 24-in. I-beam strut and the sheave platform framing at the extreme forward end. The top chord of each cantilever truss is practically a continuation of the corresponding chord of the stiffening truss on that side, but the bottom chord abuts against the hull framing, which is designed to take this thrust by the construction shown in Fig. 2 A. The cantilever structure is shown in its relation to the main stiffening structure by the view, Fig. 5. The make-up of members corresponds closely to that of the main trusses; the top chord being 10-in. channels laced top and bottom, the bottom chord 15-in. channels laced top and bottom, the vertical posts 10-in. channels laced on both sides, and the other members being made of angles laced to form stiff members.

MACHINERY FOUNDATIONS.—The foundations for the main engine, boilers and pump are carried by the bottom framing of the hull. Fig. 2 B shows the main engine foundations, and Fig. 2 C shows one of the boiler foundations. The pump foundations consist of four 12 × 13¾-in. beams bolted to the sides of the keelsons over which the pump sets.

SPUDS AND FITTINGS.—The two spuds are located at the stern quarters of the hull through which they pass by means of special casings Each spud is 80 ft. long, of which at least 65 ft. are dressed to a true cylinder 35 ins. in diameter. The spud casings are 36-in. cylinders made of sheet steel and braced to the hull timbering, as shown by Fig. 2 D. To handle the spuds two masts are built, as shown by Fig. 1. These masts are 60 ft. long, and each consists of two 8 × 20-in. pieces tapered to 8 × 12 ins. They are stepped into the floor timbers and wedged into the deck.

SUCTION PIPE LADDER.—To carry the suction pipe and cutter a steel frame ladder is hinged to the front end of the hull at the rear of the ladder well, as shown by Fig. 1. A view of this ladder loaded on cars ready for shipment is shown

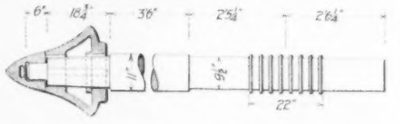

Fig. 14. Shaft for 30-in. Centrifugal Pump.

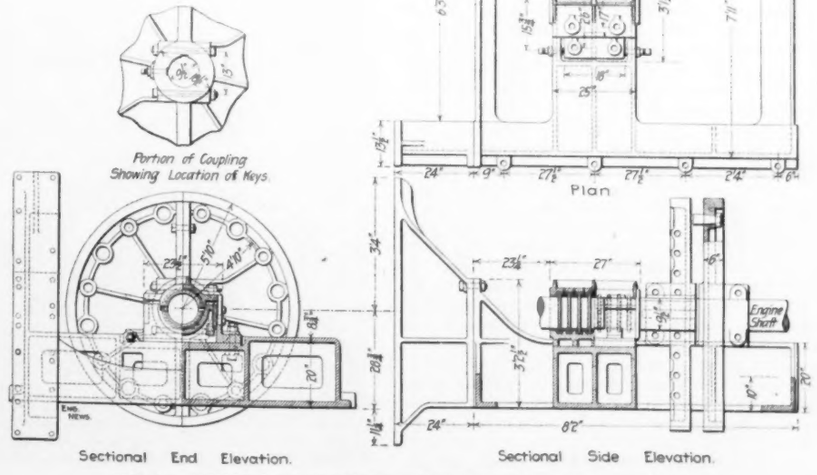

FIG. 10. DETAILS OF FLEXIBLE COUPLING AND THRUST BEARING.

by Fig. 6, and gives a fair notion of its dimensions and construction.

DECK HOUSE.—The deck house and cabins are shown in a general way by Fig. 1, and they call for little further description except the remark that they are fitted and furnished with more than usual attention to the comfort and convenience of the crew who will occupy them.

OPERATING MACHINERY.

The operating machinery of the Port of Portland dredge comprises a boiler plant, a main engine for operating the centrifugal pump, the pump itself, the rotating cutter and the engine for operating it, the engines for manœuvering the ladder and spuds, and the suction and discharge pipes. The relative locations of these machines are shown by the drawings of Fig. 1, and the succeeding paragraphs describe the construction of each in some detail.

BOILERS.—The boiler plant which supplies steam for operating the dredge machinery occupies nearly a third of the hull between trusses and abaft the midship section. It consists of two batteries of two boilers each. They are Heine water-tube boilers, and the two of each battery are placed side by side, and have a separate stack. All four boilers can be operated together or any one can be operated separately. According to the specifications, each boiler was to have 3,100 sq. ft. of heating surface, 40 sq. ft. of grate area, and not less than 150 cu. ft. of furnace space above the grates. All boilers were required to be manufactured under and to conform in all respects with the U. S. rules for the construction of boilers for steam vessels for a gage pressure of 200 lbs. per sq. in. All fittings and valves, casings, building, stacks, fronts, floor plates, etc., were specified to be of the best quality and efficiency for marine practice. The boilers were designed for green slab wood fuel.

MAIN ENGINES.—The main engines, which operate the centrifugal pump, are vertical, inverted, four-cylinder, triple-expansion engines. Beginning at the pump side there come the two low-pressure cylinders, then the high-pressure cylinder, and finally the intermediate-pressure cylinder with the following respective diameters: Low pressure 40 ins., high pressure 21 ins., intermediate pressure 34½ ins. The cylinders are supported by eight columns, four in front of forged steel, and four in the rear of cast iron. Fig. 7 is an end elevation at the low-pressure end which shows the form and position of the columns. As will be seen, the cast-iron column at the back of the cylinder carries the cross-head guides. Exactly the same arrangement is employed for each cylinder. Fig. 8 is a vertical sectional elevation along the longitudinal axis of the engine, which shows all the working parts in position. Fig. 9 is a detail of the counterbalance disk for the crank shaft. Only a few of the principal details and dimensions of the engine can be given here. In respect to the other details it may be remarked, however, that the best marine practice was adhered to in both design and workmanship.

The cylinders are of cast iron as hard as could be worked, with barrels 1¼ ins. thick, counterbored to leave a working bore of 24⅞-in. stroke. The

clearance at top is 5-16-in., and at bottom is 7-16-in. The heads are shaped to correspond with the pistons. These are of cast steel and dished, with 1 × ⅝-in. packing rings, and only sufficient clearance is provided between them and the cylinder to allow for difference of expansion. The followers are of cast steel secured by 1-in. steel studs. The piston rods are of forged steel 4½ ins. in diameter, and are fastened into the pistons by a 3½-in. nut secured by a square key. The cross head is in one

Fig. 15. View Showing Ladder and Cutter Head.

piece with the piston rod, and has a wrist pin bearing of phosphor bronze. The connecting rods are 4½ ins. in diameter at the small end and 5 ins. in diameter at the large end, with the cross-head end forked to span the cross-head. The wrist pin is 5 ins. in diameter and 11 ins. long. The crank end is enlarged to 9 ins. × 18½ ins., and is 2¾ ins. thick. The crank pin brasses are stayed to the rod by recesses fitting over a center boss turned on the end of the rod, and are lined with F. P. metal hammered into dovetail recesses.

The valve for the high-pressure cylinder is a piston valve made of cast iron in one piece and balanced, and it fits into working lining ½-in. thick forced into the casing. The valves for the intermediate and low-pressure cylinders are double-ported slide valves. The weight of each valve is balanced, the top of the intermediate pressure balance piston, being connected with the low-pressure steam chest and the tops of those of the two low-pressure cylinders with the condensers. Details of the valve stems and eccentric rods are shown by the drawings. The eccentrics are of cast iron with webbed centers and eccentricities as follows: High pressure 2 ins., intermediate pressure 2 ins., and low pressure 2½ ins. The eccentric straps are of cast steel lined with F. P. metal hammered into suitable recesses and are channeled for oil.

The bed plate is of cast iron, with a bottom 2 ins. thick extending under the whole surface covered by the top casting. The crank shaft bearings are of bronze fitted into cast-steel chocks stud-bolted to the bed plate, and are cast hollow to provide for the circulation of water. They are lined with F. P. metal, and the same metal lines the cast-iron bearing caps. The crank shaft is in two parts bolted together and having the dimensions shown by Fig. 8. The two cranks in each part are 180° apart, and the two parts are so connected that the cranks of one are at right angles to those of the other. A cast-steel counterbalance disk, Fig. 9, is attached to each crank web. As will be observed, the low-pressure end of the shaft is extended to provide for the coupling with the pump shaft.

CENTRIFUGAL PUMP.—The 30-in. centrifugal pump is mounted on a bed plate which is bolted to the engine bed plate at its low-pressure end. This pump bed plate is shown by Fig. 10, with the pump shaft, coupling and thrust bearing in place. The coupling is a cast-iron flexible coupling with steel pins and links, and of course connects the end of the engine shaft with the end of the pump shaft. Its details and those of the thrust bearing are sufficiently shown by the drawings of Fig. 10. The pump casing is to be fastened to the uprights of the bed plate, as shown by Fig. 11. Fig. 12 is a vertical axial section of the pump and main bearing, showing all parts in place. Fig. 13 shows details of the pump runner, and Fig. 14 shows the pump shaft. The specifications for the casing, main bearing, shaft and runners were in brief as follows:

PUMP CASING.—The pump casing is to be made in three pieces as shown. It is to be finished on the inside as shown, and at all joints, recesses are to be made for ⅞-in. square packing as shown, and the packing inserted at the shop. These recesses are to be of such size that the packing must be hammered in place and will extend about 1-16-in. above the surface of the metal to make a tight joint when the pump is bolted together. Three complete sets of liners of cast iron and steel plates are to be provided as shown. The cast-iron liners are to be chipped or finished at surfaces of contact, and the plate liners and rings are to be finished on the edges. The holes for fastening the liners in place are to be accurately drilled in the locations shown. All liners are to be fitted to the pump and one set is to be shipped bolted in place. All liner bolts are to be coated with white lead before being put in place, and are to have grommets of candle-wicking coated with white lead placed under the nuts.

MAIN BEARING.—The main bearing is to be constructed as shown. It is to be finished outside and inside. The holes for bolting to the pump are to be drilled 1⅞ ins., or large enough to allow ⅜-in. adjustment in any direction. A water channel is to be provided as shown 2 ins. wide, and tapped for 1½-in. pipe. The brasses are to be made of best bronze in sections as shown and filled with Flinn Metal Works special babbit. Each section is to be made in halves and the bottom piece is to slide on a feather 1½ ins. by 1 in., let into the bottom of the bearing one-half its depth. The brasses are to be finished all over and the top halves are to have enough clearance all around so they will easily slide into place. The top halves will have a notch 1½ ins. by ½-in., the same as the bottom halves, for the passage of the water of circulation, and proper oil channels will be provided in all brasses. Each top brass will have at least five ⅝-in. holes through it for the passage of water or oil to the shaft. A grease cup of one quart capacity will be provided and arranged to work against a water pressure of 60 lbs. Grooves will be turned and ½-in. square packing inserted as shown, in the same manner as for the pump covers. The glands are to be finished all over and arranged for ⅝-in. square packing. The set-screws for holding the bearing during adjustment are to be provided with lock nuts with grommets underneath to prevent leakage of air or water.

PUMP SHAFT.—The pump shaft is to be made of best forged steel as per detail and finished all over. The taper is to be turned true and to accurately fit the runners. One keyway only is to be cut in the shaft, the other key is to simply bear on the shaft and be fitted in the hub of the runner. The nut is to be of cast iron, with left-hand thread, and is to have a flat steel bar 6 ft. long for turning on and off. The nut is to be finished on the face.

RUNNERS.—Two runners are to be provided as shown. The hub is to be bored and fitted to the shaft so that the runner will turn perfectly true, and each runner must be perfectly balanced after assembling, that is, one side must not be heavier than the other side. All rivets are to be driven in drilled holes countersunk both sides.

CUTTER ENGINE.—The engine for operating the cutter is located as shown by the general plan,

Fig. 16. View Showing Discharge Pipe and Pontoons.

Fig. 1. As will be seen, the crank shaft carries a pinion gearing with a spur wheel on a countershaft parallel to and behind the crank shaft. This counter shaft is extended outboard of the engine and carries a bevel gear at its end which meshes with a bevel wheel on a jack shaft parallel with the axis of the dredge and with the cutter shaft. This jack shaft has a pinion meshing with a spur wheel on the cutter shaft. The cutter shaft extends along the ladder and carries at its end the cutter head, a view of which is shown by Fig. 15.

The cutter engine is a double tandem compound engine with cylinders 8 ins. and 16 ins. in diameter and 12 ins. stroke. The high-pressure cylinders have piston valves and the low-pressure cylinders have slide valves. All materials and workmanship are of high class, and a complete complement of tools and accessories is provided. All shafting is of forged steel and all gears are of steel.

WINDING ENGINES.—There are two winding engines, one at the bow to handle the ladder and one at the stem to handle the spuds, as shown by Fig. 1. They are horizontal double 10 × 10-in. cylinder engines, and each is coupled to a crank shaft operating by gears a counter shaft carrying four drums. Each engine has a full complement of clutches, brakes, etc.

SUCTION AND DISCHARGE PIPES.—The general arrangement of the suction and discharge pipes is shown by Fig. 1. As will be seen, the suction pipe extends from the pump to the cutter head. It is fastened to the ladder with 1¼-in. U-bolts with fir saddles underneath. The discharge pipe is made up of sections of 30 ft. × 30-in. steel pipe coupled together by rubber hose. Each joint rests on two pontoons. A swivel elbow connects the outboard portion of the discharge pipe with the fixed portion on the dredge. A similar elbow connects the suction pipe on the ladder with that on the dredge hull.

MINOR AUXILIARIES.—The minor items of the operating machinery are numerous, and can be mentioned specially in only a few cases. A water service of 1-in. galvanized pipe is provided for the main bearing at the lower end of the cutter shaft. A similar service of 1½-in. pipe is connected with the main bearing of the centrifugal pump, and to the swivel elbow at the stem. Branches are carried to the main engine as follows: A ¾-in. pipe to each crank shaft bearing; two ¾-in. pipes to each crank pin; two ½-in. pipes to each crosshead; one ¾-in. pipe to each crosshead guide; one ¾-in. pipe to each eccentric; and a 1-in. pipe to each thrust bearing. There are also provided a condenser, two feed-water heaters, a centrifugal circulating pump driven by a separate engine, water tanks, air pump, boiler feed pumps, injectors, hot well, deck pump, and an electric light plant of 150 16-c. p. incandescent lamp capacity.

ATTENDANT AUXILIARIES.

A derrick scow 51 × 22½ × 2 ft. 11½ ins., and two wood scows 110 × 32 × 7 ft. 5 ins. are provided to attend upon the dredge proper. There are also 30 double catamaran pontoons for carrying the discharge pipe. A view of these pontoons and the discharge pipe line is given by Fig. 16.

ENGINEERS AND CONTRACTORS.

As already stated, the dredge was designed by and constructed under the direction of Mr. J. B. C. Lockwood, M. Am. Soc. C. E., of Seattle, Wash., Consulting Engineer to the Port of Portland Commission. The contractors for the hull were the Portland Shipbuilding Co., of Portland, Ore. The contractors for the main engines were the Willamette Iron Works., of Portland, Ore., and those for all the other engines were the Oakland Iron Works, of Oakland, Cal., The boilers were built by the Heine Boiler Co., of St. Louis, Mo.

THE MANUFACTURE OF SLAG BRICKS AND SLAG BLOCKS.

By Edwin C. Eckel.* Assoc. Am. Soc. C. E.

In a paper on the "Utilization of Iron and Steel Slags," prepared for the "Mineral Resources of the United States, 1901," the writer briefly discussed the manufacture of slag bricks and slag blocks. A number of advance "reprints" of this paper were distributed, but it was omitted from the bound volume, and is therefore practically unobtainable. This fact, taken in connection with the number of inquiries which have been received in regard to these subjects, has caused the preparation of the present paper, in which a much more detailed discussion has been attempted.

Several plants have been projected recently for the manufacture of blocks in the United States, two of which are now in course of

*U. S. Geological Survey, Washington, D. C.

construction. At present, however, the writer can not discuss their plans in detail, as they are not sufficiently far advanced to render publicity advisable. Small amounts of both materials have been made, in this country, at several widely separated plants, but the plants above noted will be the first to commence manufacture on a large scale. The methods to be adopted at them contain many features of interest, and it is the writer's intention to describe their practice as soon as the manufacturers give him permission to utilize the more detailed data which they have furnished him.

Under the names of "slag brick," "slag tile," "slag blocks," "scoria brick," etc., two very different products have been included by various writers. In the present paper these two products have been separately described as slag bricks and slag blocks, respectively.

SLAG BRICKS.

The products included, in the present paper, under the head of slag bricks, include those which are made by mixing granulated basic slag and slaked lime, molding the mixture in a brick press or by hand, and simply drying the resulting bricks. It will be noted that the materials used are those utilized in the manufacture of slag cement; and indeed the manufacture of slag bricks may be regarded as being merely a specialized phase of the manufacture of slag cement.*

Though the slag cement industry in this country appears to be progressing very satisfactorily, no attempt has yet been made to prepare slag bricks, pipes, tiles, etc., on a commercial scale. Small amounts of slag bricks have been made for local use, and for use about the mills themselves; but apparently no effort has been made to extend the manufacture. Slag bricks made near the Atlantic coast would, of course, be subject to sharp competition from the Hudson River and Philadelphia clay bricks. In the interior, however, and particularly in the South, the clay bricks made are generally much inferior to Hudson River bricks; and should be easily forced out of the market by good slag bricks.

The slags used are basic blast furnace slags, but a somewhat greater range in composition is allowable for slag bricks than when the slags are to be used in cement manufacture. The analyses quoted in the present paper may be regarded as fairly representative of the class of slags used in slag brick manufacture. It will be seen that the silica ranges from 22.5% to 35%; the alumina and iron oxide together, from 16.1% to 21%; the lime, from 40% to 51.5%. As in slag cements, sulphur is an objectionable constituent. Much of it, fortunately, is removed during the process of granulating the slag.

The general steps in slag brick manufacture may be stated as follows: Slags of proper composition are granulated, by being run into a stream of cold water immediately upon issuing from the furnace. This causes the slag to break up into little porous particles, thereby greatly reducing the expense of subsequent grinding: Granulation also confers hydraulic properties on the slag, and removes part or all of its contained sulphur. The granulated slag is dried and pulverized. Powdered slaked lime is added in sufficient quantity to bring the total calcium oxide content of the mixture up to about 55%. This mixing, as well as the previous burning and slaking of the lime, must be carefully and thoroughly done, in order to prevent subsequent disintegration of the bricks. Usually, during or after the mixing, a small amount of water is added. The mixture is then molded into shape, either by hand or in a brick machine. After shaping, the bricks are dried in the open air, this usually taking six to ten days in dry weather. In the best practice, the bricks are retained for several months, after drying, in order that they may be well hardened before marketing.

Though over 90% of the total production of slag brick is at plants following the above methods, two other methods may be briefly noted. At a few plants the granulated slag is mixed, without drying, with the unslaked lime; the slag furnishing sufficient water to slake the lime. Slaking in this way is very imperfectly done, however; and the practice should never be followed if high-grade bricks are expected. At a few other plants, notably at the Spanish plant described below, slag is mixed with slag cement, instead of lime. This variation in practice also gives an inferior product, though not so bad as that last described.

Slag bricks vary from a grayish white to dark gray in color. They weigh less than clay bricks of equal size, require less mortar in laying up, and are at least equal to them in crushing strength. The product usually seems to find a ready market, though of course the low value of the material, relative to its bulk and weight, precludes long railroad transportation.

Slag bricks were manufactured at the Cleveland Slag Works, Middesborough, England; but the manufacture has been discontinued for some years. At this plant the wet granulated slag was mixed with "selenitic lime," instead of common lime. The selenitic lime was composed of 80% unslaked lime, 10% gypsum, and 10% iron oxide; 672 lbs. of selenitic lime sufficed for 1,000 bricks. The mixture of slag and lime was pressed to shape in a brick press; the bricks were stacked in sheds, to harden, for a week, and then in the open air for five or six weeks more, when they were ready for use. The bricks were dull gray in color, and very hard and tough. Buildings constructed of them over twenty years ago are still in good state of preservation. The manufacture of slag bricks at these works was given up for reasons not connected with the technical value of the product, which seems to have acquired an excellent local reputation.

At Vitry, France, the manufacture* of bricks and pipes is carried on at the slag-cement works. The bricks are made by mixing 60 parts of slaked lime with from 250 to 300 parts of granulated slag. Sufficient water is added to this mixture to make a firm paste, from which the bricks are molded in hand or steam brick presses. These slag bricks are useful especially for foundations or basement work, pavements, etc. "Facing brick" are made from a mixture like that for ordinary slag brick, to which sand has been added. Pipes are made from a mixture consisting of 500 kgs. of slag cement and 1 cu. m. of sand. This is made into a stiff mortar, and forced into steel molds by iron rammers. The mold is removed as soon as the ramming is finished. The pipes are then dried for three days, after which they are immersed in water for 24 hours. They are then stacked in the factory yard for several months, after which they are ready for use.

Slag bricks are manufactured† on a large scale at Kralovedvoor, near Prague, Bohemia. The slags normally used at this plant vary in composition between the following limits:

SiO_2	25.8	— 27.0%	CaO	51.4	— 51.5%
Al_2O_3	17.3	— 19.3%	MgO	0.4	— 2.5%
FeO	1.5	— 1.7%	MnO	0.0	— 0.1%
			S	1.3	— 1.8%

As the slag issues from the furnaces it is run into an inclined iron trough in which cold water is flowing. In addition to granulating the slag, a considerable portion of the sulphur is removed in this way. The granulated slag is run into tanks, from which it is carried to the mixing floor, as required, by conveyors. Here the slag is dumped into mixers, together with thoroughly slaked lime in a pasty condition. The lime is obtained by the calcination of a local limestone of the following range in composition:

SiO_2	0.2	— 0.6%	$CaCO_3$	97.0	— 98.4%
Al_2O_3 & Fe_2O_3	0.2	— 0.8%	$MgCO_3$	0.9	— 1.9%

The mixture is then molded into shape under pressure in a brick machine, with a capacity of 1,000 bricks per hour. These bricks are taken to the drying house, where they remain about eight days, at the end of which time they are sufficiently hard to stand transportation. In the size usually made, the dry bricks weigh about 4.75 kg. each, and will stand a pressure of 18 kg. per sq. cm. In color they vary from nearly white to grayish. Cement and mortar adhere to them as well as to clay bricks.

Occasionally bricks are made at this plant from slags of the following average composition, derived from the smelting of an ore different from that commonly used at these furnaces.

SiO_2	33.0%	CaO	40.0%
Al_2O_3	18.67%	MgO	2.33%
FeO	1.0%	MnO	4.25%
		S	1.33%

Bricks made from this slag are dark colored, owing to the large percentage of manganese present. More lime must be used, in proportion to the slag, and the bricks require a longer time to dry and harden than is needed by those made from the ordinary slags.

Slag bricks are made at Ekaterinoslav,* Russia, from blast furnace slags showing the following range in composition:

Constituent.	Per cent.	Constituent.	Per cent.
SiO_2	22.5 to 35.0	MgO	1.4 to trace
Al_2O_3	14.0 " 15.0	MnO	0.0 " 0.2
Fe_2O_3	3.3 " 1.1	S	0.3 " 0.4
CaO	51.0 " 45.0	Loss on heating	7.5 " 2.3

The slag is granulated, sieved in a revolving screen, dried, and ground in a ball mall. Lime is slaked and finely ground. Sufficient lime is added to the slag to bring the CaO content of the mixture up to about 55%; with slags of the range of composition above noted, the mixture will necessarily be made up of about 5 to 12 parts of lime to 100 parts of slag. The mixing is carried on in a screw mixer; and the mixed powder is then pressed in a revolving dry brick press. On issuing from this press the bricks are set aside to harden, and at the end of six days are hard enough for use. Their tensile strength is about 312 lbs. per sq. in.; their crushing strength varies from 1,250 to 5,600 lbs. per sq. in., increasing of course with age. The bricks are gray in color, well shaped, weigh less than stone, and require little mortar in laying up. They withstand temperature changes well, and are well adapted for use under water.

The manufacture of slag bricks at Bilbao, Spain, differs in certain particulars from the normal method. The slag cement plant at this point utilizes slags from the Vizcaya furnace, making slag cement according to the usual methods. One part of this cement is then mixed with four parts, by volume, of granulated slag; and formed into bricks in a press. It will be noted that in a slag brick made in this fashion the strength of the brick is almost entirely derived from the slag cement, for the granulated uncrushed slag will be almost inert.

SLAG BLOCKS.

Under this heading will be considered all those articles ("slag blocks," "slag tiles," slag or scoria bricks; etc.), made by running molten slag direct from the furnaces, into molds of the proper shape. The term slag block will be employed as a general term in order to distinguish these products from the slag bricks made by mixing granulated slag with lime, which have been discussed above.

Slag blocks, if properly made, are stronger than slag bricks. They are, however, impervious to air and moisture; and on that account dwellings constructed of them are apt to be damp and unhealthy. Their chief uses are for foundations or for paving blocks, for the latter of which they are particularly well suited.

Slag blocks have been made at many furnaces and smelters for local use. For the past 30 years or so a considerable quantity have been made in the Lehigh region of Pennsylvania, their earliest recorded use being in the slag block pavements laid in Philadelphia about 1876. Preparations are now being made to commence manufacture on a large scale, in two different states.

As both the projected plants are located in areas where they will be subjected to sharp competition from other materials, it has been decided that the blocks produced must be of the highest possible quality, if the venture is to prove a commercial success. Extensive experiments on different slags and different methods of manufacture have, therefore, been undertaken. At present the writer can only discuss the difficulties encountered in a very general way, but on the completion of the plants more details can be given.

The properties required in a slag paving block are density, resistance to abrasion, toughness, and roughness of surface. These properties are found to vary with the chemical composition of the slag, the rapidity of cooling, and the character of the molds used. By properly varying the last two factors, slags of almost any (normal) composition can be utilized. The three requisite properties first mentioned—i. e., density, resistance to abrasion, and toughness—vary directly with the rate of cooling, the slowly-cooled blocks being the best. Blocks cast in sand molds, and heavily covered

*Engineering News, Vol. 47, pp. 61-62. Mineral Industry, Vol. 10, pp. 84-95.

*Engineering News, Jan. 1, 1897.

†"Engineering and Mining Journal," April 16, 1898.

*"Engineering and Mining Journal."

with loose sand, cool very slowly, and give very much better results than those cast in iron molds. Slowness in cooling, however, requires much greater storage space than if rapid cooling is practised; and casting in sand molds demands a higher grade of workmanship than casting in iron molds.

The roughness of surface—or non-slipperiness—of blocks intended for paving use is highly important, especially as slipperiness has been the chief defect charged against slag blocks, which defect is prevalent in blocks cast in iron molds. In English practice it has been overcome by casting the block in a double size mold, having a projection inside which results in a notch on the slag block. The block is, after coating, split apart at this notch, and the rough fracture-surface of each half is laid uppermost in paving. This method of avoiding slipperiness adds considerable to the labor cost of the blocks, and is therefore not well adapted to American practice. Slag blocks cast on a sand bed are free from the defect noted (slipperiness); or at least it can be avoided if sufficiently coarse sand be used.

It seems probable that the method of molding at the proposed plants will be somewhat similar to that described below as practiced at Mansfeldt, though the amount of hand labor employed there will probably be greatly reduced so as to conform to American labor conditions.

Slag blocks manufactured by the Tees Scoria Brick Co., of Middlesborough, England, have been somewhat extensively employed* as street pavement in Rotterdam. Holland clay bricks, limestone blocks and porphyry bricks are employed in the same city, and will be useful for comparison with the slag blocks. The foundation, in all cases, is simply a bed of sand, carefully packed. The thickness or depth of pavement laid on this varies, according to the paving material, as follows: Clay bricks, 4⅛ ins.; slag blocks, 5 ins.; limestone or porphyry blocks, 6 ins. The cost of material and laying per square yard is: Clay bricks, 62½ cts.; limestone blocks, 62½ cts. to $1.25; slag blocks, $1.25; porphyry blocks, $1.56. No data as to proportions of each pavement in use, or durability of the different types, are available. The adjunct director of public works of Rotterdam stated that for light traffic the clay-brick pavements were regarded as the best; for medium traffic, slag blocks or limestone; for heavy traffic, porphyry blocks.

The manufacture of slag blocks from copper slags at Mansfeldt, Saxony, has been described† in detail by Egleston. The industry, as carried on in this locality, presents certain features of interest which warrant a somewhat lengthy abstract of the paper cited.

The slags used are high in silica, ranging from 40% to 60%. When cooled rapidly, they form a dark colored brittle glass, but if cooled with great slowness the product becomes gray and crystalline. These slowly cooled slags are both hard and tough, and therefore serviceable in the manufacture of structural material. The process employed at Krug Hutte, is as follows:

The slag, as it comes from the furnaces, is carried in slag wagons to the molding ground, where the bricks are cast. The bed of the molds is sand, which has been sieved to remove coarse particles.

The bed is then carefully gone over with a shovel, which is pressed into it an inch or so to make the sand soft. It is then smoothed over with the shovel, and into the corners a piece of iron 0.18 m. to 0.20 m. long, and 0.15 m. wide is laid, inclined so as to facilitate the passage of the slag in the slag-runners which go round the whole space.

The molding bed is then so divided by iron partitions pushed down into the sand as to give the size of blocks required. These partitions have several round holes, about 0.05 m. in diameter, near their tops, to permit the entrance of slag. Previous to use, the partitions are washed with clay and sprinkled with sand to prevent the slag from sticking to them. Around each of the molds thus formed is a space 0.20 m. wide, through which the slag flows. When all the partitions are in place, the bottom of each mold is made flat by pressing down into it a piece of sheet iron (of the same size as the compartment), attached to a handle.

When the molds are ready slag is brought from the furnace in slag wagons, and allowed to flow through the interspaces and into the molds. When the slag has about half filled a mold, a little sand is thrown on it to prevent too rapid cooling. When the molds are entirely full, they are covered with about a foot of sand, and allowed to stand for 48 hours. At the end of this time the slag is cool, the sand is shoveled off, and the iron partitions removed.

During rainy weather the molding ground is kept covered with boards until the slag is ready for pouring, and as soon as this operation is finished the molds are again covered with boards.

The blocks are usually cubes, 0.15 m. on the edge, though larger sizes and different shapes are occasionally cast. The material which has solidified in the spaces between the molds is broken up for use as road metal.

At Koch Hutte similar processes are employed. Large blocks, however, are cast in cast-iron molds, with a cover that is shut down in order to compress the slag. Similar work is carried on at Kupferkammer Hutte.

Analyses of typical slags from the Mansfeldt district are as follows:

Year	Krug Hutte. 1888.	Koch Hutte. 1888.	Eckhardt Hutte. 1888.	Kupferkammer Hutte. 1881.	Kupferkammer Hutte. 1881. Per cent.	Kupferkammer Hutte. 1888.	Sangerhausen Hutte. 1881.	Sangerhausen Hutte. 1881.
Lime	18.35	23.187	21.51	19.29	20.29	19.50	19.15	33.10	23.40
Magnesia	6.732	2.22	0.847	3.23	4.37	8.02	3.677	1.67	0.87
Alumina	14.825	17.001	16.525	16.35	15.67	18.17	17.636	4.43	7.83
Iron oxide	4.725	4.643	2.768	10.75	8.73	5.89	7.213	4.37	7.47
Manganese oxide	0.697	0.328	0.744	.....	.....	.....	0.827	.....	.....
Nickel and cobalt oxides	0.063	trace.	trace.	.....	.....	.....	0.038	.....	.....
Zinc oxide	1.165	0.692	0.934	1.26	1.11	3.57	2.056	.....	.....
Lead oxide	0.232	0.118	trace.	.....	.....	.....	0.065	.....	.....
Copper oxide	0.289	0.277	0.3	0.75	0.67	0.23	0.333	0.25	0.50
Silica	47.63	48.465	46.39	48.22	50.0	48.38	46.81	53.83	57.43
Fluor.	.....	.....	.....	.....	.....	0.99	.....	2.09	1.97
Total	94.708	96.931	90.018	99.85	100.84	99.75	97.802	99.74	99.27

An interesting example of the manufacture of tile from furnace slag is described by Braden,‡ as being in operation at a plant near Santiago de Chile.

The slag and matte are tapped from the blast furnace into a slag-pot, and, after settling for a few moments, the slag is poured from ladles into molds (6 ins. square and 1 in. thick). After filling, the molds are placed on a hearth having a movable cover, and a cover is placed upon them, as well as on the hearth. A very light heat is kept up, so that the slag cools very slowly. When the slag appears black, the molds are lifted from the hearth and the slag tiles are dumped into cold water. The slag tiles thus made are light and portable, and, when laid, tough and durable. For their manufacture, a slag carrying a considerable excess of iron has been preferred.

Slag blocks have been manufactured at a Montana smelter by a process which contrasts strongly with the practice at Mansfeldt and Santiago. The slag was poured into iron molds, built up from cast-iron plates of proper form. The process was carried on in the open air, and no covering of any kind was used. The slag, in consequence, cooled very rapidly. Though not giving as dense or tough a product as Mansfeldt practice, a great saving in time and space is effected.

A PRONY BRAKE TEST OF A HORIZONTAL TURBINE FOR THE BATES MFG. CO., LEWISTON, ME.

By William O. Webber,* M. Am. Soc. M. E.

These tests were made to determine if a pair of horizontal turbine water wheels fulfilled a guaranteed performance of 688 brake horse-power at 223 revolutions per minute and 27 ft. of head. The wheels consisted of a pair of 33-in. Victor cylinder gate turbines, placed on a horizontal shaft, located longitudinally in the end of a penstock, both wheels discharging inwardly into a single draft-tube. The wheels were designed to be directly coupled to an electric generator for power purposes.

The brake apparatus consisted of a 48-in. diameter by 26¼-in. face brake pulley rim (Fig. 1), fastened by slotted holes to two spiders fitted to a dummy shaft taking the place of the generator. This shaft was mounted in hangers turned upside down and situated axially in line with the center of the wheels. Into the end of this shaft was screwed a stud, carrying a worm on its outer end, engaging a worm wheel having 100 teeth, operating a gong which struck once in every 100 revolutions of the wheel shaft. The brake rim had an outside flange to hold the brake in place, and an interior flange to hold water inside the rim of the wheel.

The brake clamp (Fig. 2) consisted of four 4½ × ⅝-in. steel bands hinged together and fitted with 3-in. square by 26-in. long maple blocks entirely enveloping the band wheel. They were clamped together by two 1¾-in. diameter screws passing through two clamp castings attached to the ends of the brake bands. These screws were operated by a horizontal hand wheel shaft, having a 30-in. hand wheel with exterior spokes and a ratio of gears of two to one to the clamp screws. The underside of the gears fitted to the clamp screws and the wrought iron nuts into which the screws were entered formed ball and socket joints with the clamp castings above mentioned.

The main brake beam (Fig. 3) consisted of a 6-in., 14¾-lb. I-beam, securely held in the upper of the two clamp castings. At a point 10 ft. 6 ins. from the center of the brake, on the underside of this I-beam, was located a V-block, the sides of the V being at an angle of 90°. Situated directly above this point, but extending at right angles thereto, was a wrought iron lever of 10 to 1 leverage; the shorter arm being 6 ins. and the longer arm being 60 ins. This lever was fitted with three 1½-in. knife edges. From the shorter end of this lever, a link connected with a clevis sustained the outer end of the main brake beam.

The middle fulcrum was carried on two steel plates having half round grooves planed in them, and situated on the top of two oak posts securely bolted to an adjoining brick wall. To these same posts were bolted two blocks confining the motion of the main brake beam to a distance of 3 ins. From the longer end of this lever depended a scale pan, provided with weights varying from 5 to 20 lbs. each. Depending from the main brake beam, at a point about 8 ft. from the center of the brake, was a hinged piston and rod loosely fitted into an 18-in. dash pot filled with crude oil.

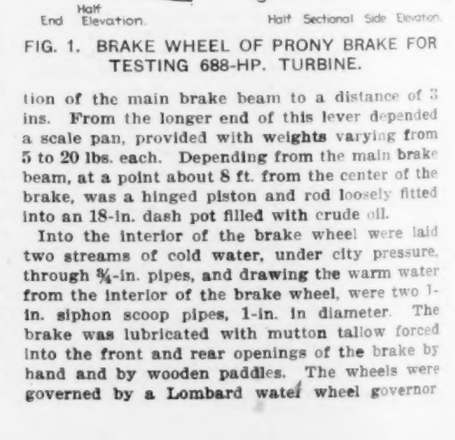

FIG. 1. BRAKE WHEEL OF PRONY BRAKE FOR TESTING 688-HP. TURBINE.

Into the interior of the brake wheel were laid two streams of cold water, under city pressure, through ¾-in. pipes, and drawing the warm water from the interior of the brake wheel, were two 1-in. siphon scoop pipes, 1-in. in diameter. The brake was lubricated with mutton tallow forced into the front and rear openings of the brake by hand and by wooden paddles. The wheels were governed by a Lombard water wheel governor

*Streets and Highways in Foreign Countries. Special Consular Report, Vol. 3, p. 190, Washington, 1897.
†School of Mines Quarterly, Vol. 12, pp. 112-117.
‡Trans. Am. Inst. Min. Eng., Vol. xxvi., pp. 52-53.
*Consulting Engineer, 53 State St., Boston, Mass.

which was left in control of the wheels during the test.

The test consisted in opening the gates by means of the wheel on the governor, immediately applying friction by means of the brake and building up the weight on the brake as the friction was applied, so as to maintain the weighing lever in a horizontal position until the desired horse-power

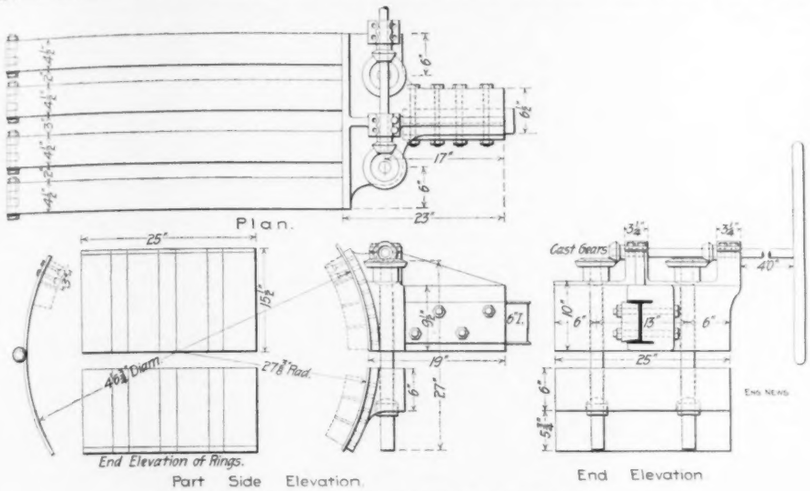

FIG. 2. DETAILS OF PRONY BRAKE BANDS.

was attained, then holding this horse-power constant for a sufficient number of minutes to obtain half a dozen readings at intervals of about 27 seconds; of the height of water in the forebay and height of water in the wheel pit, and to note the gate opening, determine the time for each 100 revolutions, by two stop watches, and note the weights on the scale pan.

From these data the average actual head of water on wheels during test was determined; the average revolutions per minute and the weight sustained, thus giving the necessary data to calculate the actual horse-power obtained under observed conditions. The head of water acting on the wheels during the test being less than 27 ft. as called for in the contract; the actual horse-power is corrected to correspond to 27 ft. head by square root of the cube of the head, or inversely as $h^{\frac{3}{2}}$ power. The results thus obtained give 703.02 and 691.30 HP., therefore, the wheels fulfil the contract requirement. The writer was assisted in these tests by Mr. Walter H. Sawyer, C. E., of Lewiston, Me., and Mr. Arthur W. Hunking, C. E., of Lowell, Mass.

CONCERNING HARDWOOD PLUGS TO HOLD SPIKES IN SOFT WOOD TIES.

At a meeting of the Scandinavian Railway Association at Stockholm, Sweden, last August, papers on the preservation of wooden ties were presented by Mr. Fridericia, Technical Director of the Danish State Railways, and Lieut. Werner, of the Swedish State Railways. In the discussion which followed, some remarks were made by Mr. C. P. Sandberg, the well-known European consulting engineer on rails and railways, and these remarks have been published as a bulletin of the International Railway Congress. From a copy of this bulletin, sent to us by Mr. Sandberg, we take the following extracts:

I have always considered the fastening of flange rails to the sleepers as one of the most important questions in railway construction. The road made with chairs, as in England, is much more costly than the road made with a flange rail, but it gives three times the bearing surface on the sleeper and is a necessity in England with its heavy traffic and high speed. The flange rail road gives the smoothest run, but the greatest weakness is that the gage does not hold so well as in the chair-made road. Two accidents have occurred in France this year owing to this weakness. Even when the weight of rails is increased, the liability of the gage to widen will always be a weak point.

Trials have been made with baseplates, but they were a nuisance in cold countries when the frost lifted the rails. Denmark uses baseplates, but the climate being less severe than in Sweden, less inconvenience in this respect is felt from their use. When the cost of the baseplate is considered, I believe more good could be done by adding that cost to the weight of the rail, and in my latest designs of rail sections the width of flange has been increased as much as is practicable in rolling and good results have followed.

Whether the flange rail is used with or without baseplates, it is the spikes that hold the gage, and the holding-power of the spikes depends on the quality of wood in the sleeper. Hard wood sleepers are obtained in southern Europe, and wood screws are used with good results; but in northern countries, soft wood, such as fir and pine, are used, and this is softer year by year owing to its immature condition. The forests are not given time enough to grow heart-timber, and the prospect for the future is not a good one if the life of sleepers cannot in some way be prolonged. Creosoting prevents decay, but the sleepers are rendered useless by the enlarging of the spike holes before decay begins, and their average life is often not more than seven years. It therefore appears to be an excellent idea to insert a hard wood plug or trenail in a soft wood sleeper to obtain a more secure road and a longer life for the sleeper. A great national saving would be the result, for large numbers of old sleepers that have been rejected on account of enlarged spike holes could again be put into service by the adoption of this method.

It is however necessary to remember that a dry or moist climate will affect the result. England, for instance, with its moist climate has long been able to make use of wooden wheel centers, but when the same were tried in Sweden, with its dryer climate, they shrunk, cracked and became loose and the wheels dangerous.

Nothing but a wide series of experiments with trenails of various sizes and made from different kinds of hard wood can settle the question in a satisfactory way, and the sooner experience is obtained in that way, the better.

For cold countries especially, such as Sweden, Canada and others, the question is of great importance and as this method has already been successfully used in England for many years and prolonged the life of sleepers for the chair roads, there is every reason to hope that the same results would follow its adoption on flange rail roads.

Economy alone should not decide the adoption of wood or metal sleepers. Conditions of climate and traffic should be considered. Where the climate is hot and the speed not great, iron sleepers have been found preferable, but in cold countries with fast running trains, wooden sleepers ensure both comfort and safety. As the power of producing timber for the world is limited, engineers should on their part make use of all available means to prolong the life of the timber they employ; if not, the world will soon be forestless, and an iron permanent way will have to be adopted as an unavoidable evil.

However, it may go a long way to prevent this unavoidable evil if the life of soft wooden sleepers could be, say, doubled by the use of plugs or trenails of hard wood, and as these trials are neither costly nor risky, it behoves railways generally to set to work with the use of plugs from whatever kind of hard wood can be the more cheaply obtained in their respective countries, and I would suggest that it should be a standing question for discussion at the International Railway Congress.

Mr. Sandberg's criticisms on tie-plates must be understood as referring to the heavy cast-iron tie-plates used in Europe; and they will hardly hold good where self-fastening steel tie-plates are used, as in this country, the tie-plates forming an integral part of the tie. These tie-plates are extensively used on American railways where heaving of the track by frost is a regular occurrence. We may note also that between the ties the additional metal in the base of the wide-based rail performs practically no useful service, and might be distributed to much better advantage in other parts of the rail section.

In our opinion a much more practical remedy for "spike-killing" than Mr. Sandberg's inserted hardwood plug, would be to abolish the barbarous spike entirely and use instead a screw spike inserted in a bored hole after dipping in paint or grease, and turned home with a socket wrench with bit-brace handle. Of course, such a rail fastening would cost a little more than spikes and would require a little more labor to put in place; but it would have far more holding power than the spike and would not cause rotting of the tie as the spike does. We believe it would more than save all its added cost in the diminished labor on the track in reducing spikes and in the lengthened life of the ties.

THE EMISSION OF HEAT FROM RADIUM has been measured by the French physicists, P. Curie and A. Laborde. Several methods were used in the experiments, employing thermoelectric couples and calorimeters. While all the results did not closely agree, they were of the same order of magnitude, and indicate that one grain of radium disengages an amount of heat near 100 gram-calories per hour. This radiation equals about 311 ft.-lbs. per hour per gram of radium, or about 140,000 ft.-lbs. per hour per pound of radium. This means that 7 lbs. of radium would continuously disengage heat equivalent to one horse-power.

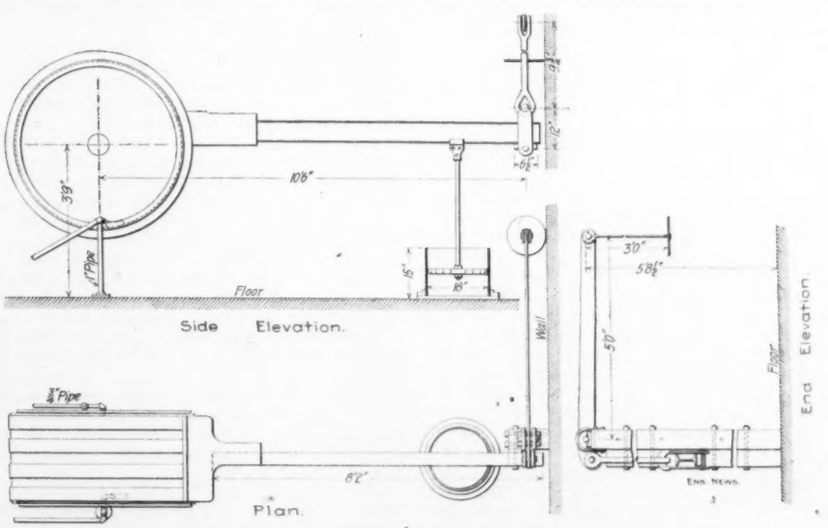

FIG. 3. BRAKE BEAM AND CONNECTIONS FOR PRONY BRAKE.

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In our issue of April 16, we strongly condemned the proposal to wipe out from the constitution of New York the present prohibition of the issue of State bonds to run for a longer period than 18 years.

The amendment embodying this was passed by the legislature, but in the debate upon it Senator Malby said:

> This is a measure to notify this generation that it will not be required to pay for all the crimes it commits, but that some of them will pass on to posterity as an inheritance from their forefathers.

Fortunately this amendment has to run the gauntlet of next year's legislature and after that must be submitted to popular vote. It seems certain that before it can reach final success, its iniquitous character will lead to its defeat.

As our readers will recollect, this constitutional amendment has been brought forward for the sole purpose of allaying public opposition to the $101,000,000 bond issue for canal improvement and voters are being-urged to approve the scheme on the ground that "steps are being taken to make the bonds extend for 50 years."

The fact is, however, that it is extremely doubtful whether it is possible to make any such alteration of the canal bond issue, should it be approved by popular vote next November. The text of the law is explicit. It specifically imposes, "for each year after this act goes into effect until all the bonds issued under the authority of this act shall be due, an annual tax of 12-1000 mill on each dollar of valuation of the real and personal property in this state" for each million dollars in bonds outstanding.

If the act is approved by popular vote next November, this tax will and must be assessed. It matters not how much income the state may have from other sources of taxation, nor what constitutional amendments may be enacted in later years. These cannot alter the existing law after it has been made effective by a popular vote.

It may be said, however, that if the 50-year bond amendment should pass the legislature of 1904 and be approved by popular vote in the fall of the same year, the way would then be open to amend the $101,000,000 canal bonding law so that the bonds would run for 50 years instead of 18.

Suppose every step of this process could be successfully taken, an interesting question would then arise as to who had the power to amend an act after its submission to popular vote. The legislature could hardly have this power, for that would nullify the whole idea of the referendum vote. If this could be done, it would be within the power of the legislature of 1904, for example, to repeal in toto the barge canal bill, after its approval by popular vote.

The referendum vote is so new a thing that court decisions regarding it are yet to be made. It would seem almost certain, however, that a law once submitted to approval by popular vote can only be repealed or amended by a second resort to the referendum.

It may well be questioned, however, whether the passage of a separate amendment to the canal bonding law at a separate time would not be apt to place a cloud on the legality of the entire bond issue. It may also be questioned whether this is not perfectly well known at the present time to those who are advocating the barge canal.

We ask the question point-blank of the men who are pushing the barge canal scheme: Are you not well aware that it will be practically impossible to make the canal bond issue run for fifty years; and is not your reference to this in your "canal catechism" a deliberate attempt to mislead the voters of the state? If not, will you please explain to the voters exactly what steps can be taken to make the bonds extend for fifty years?

The Buffalo "Express" attempts to answer our argument against the issue of long-term bonds by the State, and it cites the practice of some railway companies in issuing long-term bonds. "If it is good business for a railway company to bond for 100 years ahead," says the "Express," "by what process of reasoning can it be held unbusinesslike for the State to bond for 50 years?"

If our contemporary will carefully compare the situation of a railway stockholder and of a State taxpayer, it will find that its argument falls to the ground. If it were proposed to issue this $101,000,000 in bonds merely on the security of the earnings of the barge canal to be built with their proceeds, and if the taxpayers of the State were under no obligation to pay these bonds, principal or interest, except from the earnings of the canals, then objection to making the bonds run for fifty years might disappear.

Or we may put the case another way. Would the stockholders of a railway company issue long-term bonds if they had to pledge for their payment not only the railway and its earnings, but every dollar of their other property, real and personal, and that of their heirs and successors?

If our contemporary will investigate, it will find that bonds issued by States and cities are regarded as debts, to be paid at a definite time, whereas bonds issued by a railway company are generally regarded as a mere contingent liability in which the bondholder is really a partner in the enterprise with a preferred claim to the profits and assets. We know of no State or municipality which has any such large bonded indebtedness due a half-century hence, as it is proposed by the canal advocates to place upon New York.

The prosperity of the electrical manufacturing business is brought to public attention by the financial report of the General Electric Co., just issued. In the year ending Jan. 31, 1903, this company reports total sales amounting to $36,685,598, and profits amounting to $10,277,169, after deducting all expenses of every nature and allowances for depreciation. This would indicate that of the average price at which the company sold its products nearly 28% represented clear profit, over and above all expenses of every sort. Remembering what a large proportion of the expenses of the company are represented by the sales department, general expenses, installation expenses, etc., it is evident that electrical apparatus is now being sold at prices which represent a great advance over its factory cost.

Another interesting feature of the report is that the above enormous output was produced by the company from factory plants which are valued at only $5,000,000. The company's consolidated balance sheet shows assets as follows:

Cash on hand	$6,432,556
Stocks, patents, real estate (other than factory plants), notes and accounts, and work under way	27,050,734
Merchandise inventories	11,561,216
Factory plants	5,000,000
Patents, franchises and good will	2,000,000
Total	$49,982,506

If this is a correct showing, then the company's factories produced goods of a selling value equal to the entire cost of the factory producing them every 50 days throughout the year. We believe there is hardly a branch of highly specialized manufacturing industry in which the value of the product is so great in proportion to the value of the plant for its production.

We make this comparison, of course, on the assumption that the $5,000,000 assigned to factory plants above is a fair estimate of the cost of reproducing the company's existing factory plants as they stand. It may be that this item has been "written down" in the balance sheet, though it is difficult to imagine any reason for doing this when the other items in the list of assets are so huge.

Discussing the recent decision in the Northern Securities case the "Journal of Commerce" says:

> Why should not the National Government require all railroads engaged in interstate commerce to be incorporated under a Federal statute which shall clearly define their privileges and obligations and make plain the limitations under which they are to operate?

We may answer this question by asking another: Why should not the National Government require the incorporation under a Federal statute of all companies conducting an interstate business? Of course the objection will be raised that this will lead to undue centralization of power in the federal government and there will be opposition to the proposal to turn over to Congress and particularly to the all-powerful Senate the sole responsibility for controlling and regulating the great industrial corporations. These objections, however, are more apparent than real. State regulation of corporations has been thoroughly tried and has proved a thorough failure. Even if means could be devised for subjecting the great corporations of the present day to state control, recent experience in Missouri and in Delaware illustrates the results that would certainly follow.

The enactment of a national incorporation law will be a logical evolution from the action taken by the last Congress in creating the bureau of corporations.

The Park Ave. tunnel collision of Jan. 8, 1902, has resulted in verdicts for damages against the railway company amounting to about half a million dollars, and the trial for manslaughter of the engineer who ran his locomotive into the rear of the train ahead. The latter trial was held in New York last week and resulted in the acquittal of the engineer, Wisker. The jury apparently took the view that his failure to see the green signal and bring his train under control, and his failure to obey the rule requiring a signal not seen to be observed as a signal at danger, did not constitute sufficient negligence to constitute manslaughter, notwithstanding the fact that it resulted in the death of 17 passengers and the injury of many others.

Public sympathy was undoubtedly with the engineer, and the blame for the accident was placed by the public on the railway management for the conditions under which the tunnel was operated.

From the testimony in the trial it appears probable that Wisker was nervous over his new duties and responsibilities when he took charge of his train on the morning of the collision. He had only just been promoted from a fireman's position; and although he had run through the tun-

nel 3,100 times as a fireman, he became rattled when he failed to make out the distant signal at 63d St., and did not realize that he had run past it until he saw the red home signal, when it was too late to stop before striking the train ahead.

So far as Wisker is concerned, the punishment he must daily suffer in the knowledge that his failure cost so great an amount of death and suffering could hardly be added to by any term of imprisonment. The important point from the standpoint of public safety is the effect which his acquittal or conviction would have on the thousands of other locomotive engineers who carry so great a burden of responsibility. It is sincerely to be hoped that their knowledge of Wisker's failure to obey a signal and its terrible consequences may be as effectual a lesson to them as any term of imprisonment for him could have been.

CONCERNING RAILWAYS OF LIGHT TRAFFIC.

The existing mileage of railways in the United States is reported by the statisticians as a little over 200,000 miles; and people are prone to think of this figure as representing a certain definite quantity. We speak as if a mile of railway were a certain, fixed thing; as if each mile of railway were like every other mile; as if each represented approximately about the same investment and about the same amount of transportation service.

This idea is held not only by people generally but to a not inconsiderable extent by engineers as well. In proof of this we can do no better than to quote from the late A. M. Wellington's "Railway Location," without doubt the ablest treatise on railway economics ever published.

> In spite of enormous differences in traffic, there may still be said to be a certain average standard to which the vast majority of the railways approximately conform, or begin to do so almost as soon as the track is laid. Between the 12,000 to 14,000 miles of trunk lines or sections thereof, which make nearly half the earnings and carry far more than half the traffic of the country, and the 113,000 to 115,000 miles which manage to live on the rest of it, or on less than one-tenth as heavy an average traffic, there are indeed considerable differences of condition; yet the resemblances—in rails, in ties, in ballast, in rolling stock, in alinement—are still more striking.

It is important to note that the above quotation was written 17 years ago; and that enormous changes have taken place since that time, not in the condition of the railways of light traffic, but in the development of the heavy traffic roads. When Mr. Wellington wrote, the era of heavy rails was only beginning, and many trunk line roads were still using 52-lb. rails. Now the contrast is between 100-lb., and even 110-lb. rails at one end of the scale and 26-lb. rails at the other. The trunk line road uses heavy oak ties costing 50 cts. to $1 each. The light traffic railway gets along with the cheapest ties that it can find, costing, perhaps, only 10 to 15 cts. each. The trunk line road uses broken stone ballast costing perhaps $3,000 per mile; the light railway gets along without any ballast at all.* The trunk line road has spent millions of dollars in paring down grades and flattening curves; the light traffic railway is laid out with curves reaching 20° to 25°, and grades as steep as its locomotives can crawl up and haul two or three cars or even a single one. In rolling stock the contrast is greatest of all. The huge freight or passenger locomotives of the trunk line road may be five times the size of the locomotives on a light traffic railway.

Now let us turn to the contrast in density of traffic. For the one extreme, take the enormous traffic of the main four-track line of the Pennsylvania Railroad between Pittsburg and Philadelphia. The average density of last year's freight traffic over this 330 miles of road was 23,764,530 ton-miles per mile. If we assume that this freight movement was made on 320 days of the year (allowing for a movement at one-third the average rate on Sundays and holidays) we have an average daily movement of 74,265 tons of freight. If we allow 1,000 tons as the average load of a freight train on the main line, such a freight movement would require 37 such trains each way daily every 24 hours.

We can only appreciate how great this traffic is in comparison with the average traffic of ordinary railway lines by making comparisons. The last Interstate Commerce Commission's statistics show an average density of freight traffic of 760,414 ton-miles of freight per mile of road per annum for the whole United States, and averages of 384,000 to 450,000 ton-miles per mile for the railways west of the Mississippi and Missouri Rivers. These geographical averages are raised, however, by the heavy traffic on the main line roads. When we come to the branch lines, the spurs, and the roads built to reach a mine or tap a timber tract, we find that the traffic moved is frequently only 50,000 to 100,000 ton-miles per mile of road per annum, and on not a few roads it falls below the lowest of these figures.

Thus, while to the superficial observer, all railway lines look alike, when regarded as avenues for traffic there is as great a difference between different railways as there is between a crowded street in a great city and a quiet country road.

And now let us return to the figure of 200,000 miles, representing the extent of the railways of the United States, and inquire what it really stands for. What part of this 200,000 miles belongs to the railways hauling a trunk line traffic? What part represents the railways of medium traffic, hauling, say, 100,000 to 500,000 ton-miles of freight per mile of road per annum? What part belongs to the railways which haul less than 100,000 ton-miles per annum per mile of road?

There are nowhere any statistics which furnish an answer to this question. Mr. Wellington, in the paragraph above quoted, estimated the railways hauling a trunk line traffic at 12,000 to 14,000 miles. Probably this estimate should be more than doubled at the present day. Some light on this is thrown by the statistics of double-track mileage. There are, by the last report of the Interstate Commerce statistician, a little less than 13,000 miles of second track in the United States. Remembering how traffic has grown on single-track lines in the Far West which had little more than local traffic a score of years ago, it is probable that there are now as much as 30,000 miles of railway in the United States with a traffic sufficiently dense to make them rank as trunk lines.

Turning now to the railways of the third class, the branch lines, spurs and feeders, the lines in thinly settled districts, we shall make an estimate which will doubtless surprise many of our readers. We think it probable that half the railway mileage of the United States outside of the trunk line mileage has an average traffic of less than 100,000 ton-miles per mile per annum.

Let us get a clear idea of what such a ton-mileage represents: If trains are operated 300 days per year, only 333 ton-miles per mile per day will be required to amount to 100,000 ton-miles in a year. Thus a railway running two freight trains each way daily with an average load of only 82 tons will have a traffic of 100,000 ton-miles per mile per annum.

We have estimated above that such a traffic is as much as exists on half the railway mileage of the United States. Whether this is above or below the mark is unimportant. The main point to which we wish to direct attention is the enormous extent and importance of railways of light traffic in the United States, and the extremely meager information concerning such railways to be found in technical literature. The treatises on railway construction and operation, and the publications devoted to them are almost exclusively taken up with matters relating to the railways of heavy traffic. The art of building and profitably operating railways which can obtain only a light traffic is almost wholly unrecorded in technical literature.

Unfortunately the principles applicable to trunk line roads have not infrequently been adopted in the construction of railways of a different class. A great many railways which are now numbered among the lines of thin traffic were originally projected as through lines. They were launched during a boom period when every town was aspiring to be a city, and money was lavished on their construction. The financial result of all such enterprises has invariably been disastrous.

In the whole science of economic transportation there is no more cardinal maxim than that the character of the road should be governed by the volume of traffic it is to carry. If a railway is to carry a traffic of several hundred thousand ton-miles per mile per annum, it will pay to spend money to reduce grades and curves and improve the roadbed to enable heavy trains to be hauled. If, on the other hand, a train or two a day will carry its entire traffic, then the best road is that which can be built for the least money, and which will cost least to maintain. The big items in the annual payments of a light traffic railway company are not the cost of train service. They are the interest on the money invested in the road and the cost of maintenance of way.

In the admirable little treatise of Mr. E. H. McHenry on "Railway Location and Construction" engineering is defined as "the art of making a dollar earn the most interest," and he continues:

> The combined sum of operating expenses and interest charges is least when interest charges on additional expenditures are no longer saved in reduced cost of operating expenses, and when additional operating expenses are no longer saved in reduced interest charges.

The economical construction and operation of railways of light traffic is of large importance, because the great bulk of the railway mileage now being constructed and to be constructed in the future is of this class. There is no lack whatever of through railway lines to handle the country's traffic. Where traffic exceeds the ability of the railways to handle it, as has happened within the past year or two in some sections, the true remedy is not the construction of new railways, but the double-tracking of existing single-track roads. Of course there will be an occasional new through line constructed; but in general the great bulk of future railway construction will be branch lines, and feeders, which will in most cases have only a light traffic to handle.

For these reasons it seems to us that the construction and operation of such railways is deserving of more attention in technical literature than it has received. Unfortunately, notwithstanding the enormous extent of "thin traffic" railways in America, accurate data concerning most of them are not to be had because they have been absorbed by the great companies, and their traffic, earnings and expenses are not separately reported. The student of the subject, therefore, has to confine himself to the railways which are still operated independently.

The state of Maine offers a very interesting field to the student of light railway operation, because there has been tried there a more radical experiment in the building of narrow-gage railways than has ever been attempted anywhere else in the United States. The question of narrow gage vs. standard gage was pretty well threshed over a quarter of a century ago, and it is now universally agreed that wherever in the United States it will pay to build a 3-ft. gage or 3-ft. 6-in. gage railway, it will pay better to build a standard-gage road, over which the freight cars from any other railway can be hauled without transfer of lading. The narrow-gage railways of Maine, however, have the very narrow gage-width of 2 ft.; and it has been claimed that with a railway of this size there was obtained a great enough reduction in the cost of road and equipment to make the system more economical than the standard gage for lines of very light traffic.

We have compiled from the annual report of the Maine Railroad Commission for 1902, recently received, some statistics of the cost, traffic, earnings and expenses of these roads, and also of a number of independently-operated standard-gage roads in Maine, which also carry a light traffic, and the matter is presented in the table on the following page. Before discussing the figures, a word of comment as to the character of the different roads is essential.

It will be seen that the five standard-gage roads divide at once into two classes. Three, the Rumford Falls & Rangely Lakes, the Somerset and the Washington County R. R., we judge by their cost per mile to be roads built on ordinary steam railway standards, with care to keep grades and curves within reasonable operating limits. The Georges Valley and the Sebasticook & Moosehead Railways are lines which have been built as cheaply as possible, and the very low figure of

*The recent report of the committee on ballasting of the American Railway Engineering and Maintenance-of-Way Association (Eng. News, March 26, 1903) opened with the statement that less than half the railway mileage of the country has any ballast at all.

LIGHT-TRAFFIC RAILWAY LINES IN MAINE, AND THEIR RECORDS OF OPERATION IN 1902.

Items.	Standard-gage roads. George's Valley.	Rumford Falls & Rangeley Lakes.	Sebasticook & Moosehead.	Somerset.	Washington Co.	2-ft. gage roads. Bridgton & Saco River.	Franklin & Megantic.	Kennebec Central.	Monson.	Phillips & Rangeley.	Sandy River.	Wiscasset, Waterville & Farmington.
Length in miles	8.50	32.73	15.00	42.06	136.33	21.25	31.66	5.00	8.16	28.60	18.00	57.40
Cost of construction per mile	$9,527	$20,025	.....	$24,776	$31,780	$10,215	85,611	$12,303	$7,500	$8,354	$12,352	$12,394
Weight of rails per yard	56 lbs.	60 and 65	50 lbs.	50 and 70	60 lbs.	30 and 35	25 & 35	25 lbs.	30 lbs.	35 lbs.	35 & 52	.....
Density of traffic:												
Passenger-miles per mile of road, per annum	.....	13 471	.....	22,681	37,108	14,263	7,150	58,000	3,329	10,447	24,741	5,153
Ton-miles freight per mile of road, per annum	.....	72,445	.....	85,032	56,499	14,940	18,726	6,274	7,099	6,318	29,712	9,095
Revenue train-miles per annum per mile road:												
Passenger	.....	700	760	1,270	1,200	225	900	4,200	.....	780	1,580	180
Freight	.....	900	...	1900 (	560	...	450	.....	400	.....	750	120
Mixed	.....	77	642	( )	250	1,720	300	197	1,680	630	80	480
Total revenue train-miles pr annum pr mile road	1,180	1,750	1,400	2,170	2,000	1,950	1,840	4,400	2,030	1,430	2,420	800
Operating expenses per revenue train-mile	102.4 cts.	128 cts.	73.3 cts.	107.3 cts.	65.8 cts.	70.6 cts.	61.5 cts.	47.8 cts.	56.4 cts.	67.5 cts.	66.6 cts.	57.7 cts.
Average fare per passenger-mile	.....	.....	.....	2.83 cts.	2.33 cts.	4.60 cts.	4.23 cts.	2.00 cts.	5.00 cts.	3.64 cts.	3.74 cts.	2.57 cts.
Average freight rate per ton-mile	.....	.....	.....	2.73 cts	1.40 cts.	6.90 cts.	4.04 cts.	2.83 cts.	7.87 cts.	5.52 cts.	5.96 cts.	3.80 cts.
Average passengers in a passenger train	.....	14	.....	17	26	7	5	13	2†	7	11	22
" tons of freight in a freight train	.....	74	.....	95	71	8	25	32	3.5	10	36	11
" cost of maintenance of way per mile	$338	$930	$416	$800	$327	$380	$420	$438	$414	$385	$422	$179
Gross earnings per mile of road	$1,475	$3,092	$1,080	$3,187	$1,921	$1,903	$1,156	$3,115	$793	$896	$2,880	$434
Operating expenses per mile	1,206	2,239	1,028	2,326	1,313	1,363	1,134	2,100	932	968	1,630	438
Net earnings per mile	269	852	52	860	608	540	22	1,014	−139	−72	1,250	−4

†Only mixed trains are run.

$9,527 per mile given as the cost of the former is certainly remarkable. The cost of the Sebasticook & Moosehead road is not given, but we understand it is also very cheaply built.

Turning to the narrow-gage roads, the Kennebec Central and the Monson R. R. are short local lines, the former carrying chiefly a passenger traffic and the latter reaching some slate quarries. Their statistics are, therefore, of less value for our present purpose than those of the other narrow-gage roads. The Franklin & Megantic, the Phillips & Rangely and the Sandy River roads form a connected system in northern central Maine, and are subjected for part of their business to the competition of the Rumford Falls & Rangely Lake standard-gage road, which is a line of recent construction. The Bridgton & Saco River road is a line by itself with no competition. The Wiscasset, Waterville & Farmington parallels the Maine Central road; but at a considerable distance, so that it should be able to command its own local traffic.

Looking at the figures of cost of construction per mile of these 2-ft. gage roads, it appears evident that something has been saved in first cost over standard-gage construction, but the amount saved is probably not as great as the comparison with the standard-gage roads given in the table would indicate. The very low cost of the Franklin & Megantic must be either a matter of bookkeeping or else due to some particularly favorable topographical condition. Probably $12,000 per mile for a typical 2-ft. gage road as compared with $20,000 per mile for a standard-gage road built with equal regard to economy in first cost would be the limit of advantage in first cost which could be assigned to the 2-ft. gage. Reference to the figures for weight of rail shows that the 2-ft. gage road with its light rolling stock saves something on rails and doubtless on bridges as well in the original construction.

Reference to the figures for density of traffic shows that the narrow-gage roads have indeed to get along on very scanty rations. The Sandy River road with an annual traffic per mile per annum of about 25,000 passengers and 30,000 tons of freight makes a very fair financial showing, but it has to charge nearly 4 cts. a mile for passengers and nearly 6 cts. a ton-mile for freight to do it. The Bridgton & Saco River line has about half as much traffic and by charging still higher rates for its carriage it manages to earn a low rate of interest on the invested capital. The other narrow-gage companies (except the Kennebec Central, which appears to do a street railway business), are certainly losing ventures financially, chiefly, it would appear, from the fact that they have not traffic enough to live on. The longest of the narrow-gage lines, the Wiscasset, Waterville & Farmington, has been completed only recently, which perhaps explains in part its very thin traffic.

Turning to the standard-gage roads, the figures for density of traffic of the two cheaply built roads are unfortunately not given, but their figures of gross earnings per mile indicate that the traffic must be exceedingly thin. Of the three higher class roads, two (the R. F. & R. L. and the Wash. Co.) are of comparatively recent construction, so that each can fairly expect a considerable growth from their present traffic. Comparing their traffic with that on the 2-ft. gage roads, these standard-gage lines are doing a large business; but it will be evident from their figures of earnings that their profits are at present insufficient to give more than a very meager return on the capital invested. This is partly due to the fact that their rates of fare and freight are considerably lower than the rates on the 2-ft. gage roads. Practically the patrons of the road are receiving the carriage of their goods and themselves at less than its actual cost; a condition which it is altogether probable prevails on a very large proportion of the railways of the United States having less than 100,000 ton-miles of freight traffic per annum per mile of road.

Not less interesting than the figures showing density of traffic per mile are the records showing the train miles run per annum per mile of line. Judging from the face of the returns, all these thin traffic railways seem to be running more frequent trains than they can afford. The Wiscasset, Waterville & Farmington is being operated most economically in this respect, its train mileage amounting to only 800 miles per mile per annum. This is accounted for probably by one daily mixed train each way every day and extra freights, excursion trains, etc., run whenever they are required.

We are well aware that it is often urged that the way to make traffic grow is to furnish facilities for it, and that frequent train service is a necessity if a railway is to be developed. Such arguments are well founded where there is a chance of building up passenger traffic, as in suburban regions or even in thickly settled farming districts; but they are not applicable at all to such lines as those we are considering. The fact is that passenger traffic on thin traffic roads does not pay, except where it is carried in mixed trains. The table before us is good proof of this fact. Take any one of these roads and multiply the average receipts per passenger per mile by the average number of passengers in a passenger train and you have the average gross earnings of passenger trains per mile run (except for a trifle from express and mail carriage). Compare this figure with the average operating expenses per revenue train mile and it will be found in nearly every case the passenger business is being done at an actual loss or is paying little or nothing in the way of profit.

The thin traffic road, then, must be operated with an eye to freight traffic and not passenger traffic if it is to be a paying enterprise, and frequent train service is of no importance at all in handling freight traffic. From this point of view, when we compare the freight train mileage on some of the these roads with the average freight train load, it would seem that the number of trains could well be reduced with advantage to the owners of the roads. It will be noticed that four of the narrow-gage roads report average freight train loads of only 11, 10, 8 and 3½ tons, respectively. This, with such average passenger train loads as 2 passengers, 5 passengers, 7 passengers, 11 passengers, give one an idea of what a sparse traffic these railways have to gain their living from.

A noteworthy fact is that the operating expenses per train mile of the standard-gage Washington County R. R. are very little more than the average of the 2-ft. gage roads. This is partly due to the fact that its maintenance of way expenses were abnormally low and also to its much greater length compared with the others.

It will not escape attention that all these operating expenses per train mile are rather high compared with what is sometimes reported. The explanation is probably found in the large percentage of the operating expenses which are due to maintenance of way. On a thin traffic road it is the cost of keeping the track in running order that spoils the chances of dividends.

The very low cost of maintenance per mile reported for the Washington County and for the Wiscasset, Waterville & Farmington are probably due to these roads having been recently completed and hence requiring probably no rail, tie, or other renewals last year. Coupled with this was doubtless the fact that the company's treasury in each case could spare nothing except for absolutely necessary expenditures.

All the other 2-ft. gage roads show such a similarity in figures for the cost of maintenance of way that the average may be accepted as reliable, and $400 per mile may be taken as a fair average figure of cost of maintenance of way on these 2-ft. gage roads. We may mention incidentally that these roads pay only 10 to 15 cts. apiece for ties, and if they were not located in a forested region their expenses in this department would naturally run much heavier.

Of the standard-gage roads the figures of $338 per mile for the Georges Valley and of $416 per mile for the Sebasticook road are not be taken as a standard for average annual cost in view of the fact that these roads had very little money to spend. The Somerset road's expenses probably represent a fair average for the cost of maintenance of way of standard-gage roads carrying their traffic under average conditions. It often is done for very much less than the $860 per mile there reported, but with permanently higher prices for ties, for labor and for lumber—the three big items in the maintenance of way expense account—a higher average must be expected in the future than has obtained in the past on American railways.

Looking finally to the financial results of the year's operations, it must be said that they are certainly not encouraging to the promoter or investor in railways of thin traffic. Only two roads out of the dozen in the table earned a really satisfactory rate of interest on its cost and one of these handled practically a street railway traffic, seven-eighths of its earnings being from passengers. It will be found true, we believe, that wherever lines of thin traffic are returning satisfactory dividends to their owners, they are doing it by charging rates of fare and freight sufficient to permit such a return.

This is perhaps the most important lesson to be gained from the contrast we have tried to draw between the great railways and the small—that traffic rates should be proportioned to the necessary cost of service, which is of necessity vastly greater on a thin traffic road than on a railway operated at something like its capacity.

We have been accustomed to deal with averages in these matters and have failed to set the different roads in classes by themselves. These thin traffic roads perform a most important pub-

lic service to the communities which they enter, and they ought to receive the fair cost of this service, even if this makes necessary the raising of fares and freights. The idea of a fixed rate per ton mile or per passenger mile on all sorts of railways is wrong, and the differences which have existed are not by any means sufficient to equalize variations in conditions. A charge of 10 cts. per ton mile or per passenger mile on a thin traffic road may be as fair and reasonable a charge as one-twentieth of that sum or even less would be on a great trunk line railway.

LETTERS TO THE EDITOR.

A Method of Reducing Square Feet to Square Yards

Sir: The following method of reducing square feet to square yards may be of interest to some of your readers. For instance to convert 763.0 sq. ft. to sq. yds., write the 7 as a repitend, placing the decimal point one place less to the right than it occupies in 763.0, and follow the same rule for the other numbers. We then have

77.77 +
6.66 +
.33 +

84.76 sq. yds.

Yours truly,

J. M. Rudiger.

114 S. Elliot Place, Brooklyn, N. Y., April 21, 1903.

Breaking Boulders by Mud-Blasting.

Sir: The question of Mr. Claude Filkins in your issue of April 9 brought to my mind statements which were made to me by several laborers who were employed during the construction of the Oregon & California R. R.

According to those statements boulders on the right of way were broken by placing one or more sticks of dynamite on top of the boulder and covering it with one or two shovelfuls of snow or dirt, which they called a "blanket." The powder was then exploded, shattering the rock. And while the weight of the "blanket" was practically nothing, it required a far greater charge of powder to do the work without it. Yours truly,

John Ryan.

St. John, Cal., April 18, 1903.

A Warning Against an Impostor.

Sir: Within the last 30 days I have received letters from three engineers in the Northwest stating that they had been called upon by a young man who called himself Earle Clayton and represented himself as being a son of mine and asked for a loan of a few dollars until he could get a remittance from home. This young man is evidently an impostor, as I have no children, and I would be glad if you would publish a notice in your paper giving this statement, so as to put the profession on their guard. It is extremely humiliating to me to be thus placed before the public and I know of no better way to stop it than by asking your assistance. Very truly yours,

R. M. Clayton, City Engineer.

Atlanta, Ga., April 16, 1903.

Transportation of Dynamite.

Sir: Having noticed in the Engineering News many articles relating to the dangers connected with the handling of dynamite and references to accidents in connection with its use, we would call your attention to the following report of an accident which occurred at Sunbury, Pa., in the transportation of dynamite:

Upon arriving at Sunbury to investigate the reported wreck in which there was a carload of dynamite in the train, I saw Mr. Nathan Strain, who was the only person I could find who was an eye-witness to the accident. Mr. Strain was about 150 or 200 ft. away from the scene of the accident and his report was as follows:

The accident occurred about 7.30 o'clock in the morning on April 13. The first train in which the car of dynamite was, had been signaled by the towerman to go ahead. About 500 yds. from the point at which the accident occurred the P. & R. R. R. crosses the Pennsylvania R. R., and after the engineer had given the signal to go ahead the towerman gave him a signal to stop as a Pennsylvania R. R. train had the right of way at the crossing. The train was immediately stopped, but as the second section was following close to the first one, the flagman was unable to signal them in time to stop, and consequently the second section ran into the rear end of the first section. The car containing the dynamite was the fifth car from the caboose with about 35 cars between it and the engine. The four cars immediately behind the car of dynamite and in front of the caboose were loaded with galvanized iron pipe. When the crash came the caboose and car ahead of it were smashed into splinters and immediately caught fire from the sparks from the engine. The car of dynamite crashed into the empty car ahead and lifted it so that the greater portion was on top of the car containing the dynamite. The dynamite car was almost a total wreck, a large portion of the boxes were broken and the contents scattered on the ground, but no explosion occurred. As soon as the train caught fire someone sent in an alarm and the Sunbury fire department came and put the fire out. The car containing the dynamite was P. & R. No. 14,102, and contained 800 boxes of dynamite.

I visited the scene of the accident on my arrival at Sunbury and found that the wreck had been cleared up and traffic had been resumed five or six hours after the accident had occurred. I was unable to get a photograph of the wreck, but gathered up a few pieces of the boxes which had not been removed and have forwarded them to you under separate cover. The car containing the dynamite and the car ahead of it were almost a total loss and I am informed by the freight agent of the P. & R. that a large number of broken dynamite boxes and the contents were gathered up and placed in barrels, boxes, etc., loaded into a car and sent on to destination.

We have in our files reports of many cases where cars of dynamite have been wrecked in transportation without any explosion resulting, and simply quote the above report as the most recent case, although hundreds of similar instances could be cited. Yours very truly,

Repauno Chemical Co.,
Chas. L. Patterson, G. S. A.

Wilmington, Del., April 23, 1903.

Civil Engineers in the Navy and in the Army.

Sir: Will you please publish the duties of "a full civil engineer"; and an assistant civil engineer of the navy and the corresponding positions in the army, together with the salary and requirements of each position. Your article in the issue of March 26 on the navy bill recently passed is what prompted the above questions and no doubt there are other "young engineers" who would like to know.

Yours very truly, L. T. Boyle.

Gulfport, Miss., March 29, 1903.

(Nearly all of the civil engineering work under direction of the Army is under direction of officers of the Corps of Engineers, all of whom are graduates of West Point. Their assistants appointed from civil life are designated "Assistant Engineers," no matter what their length of service. Their pay is generally small in proportion to the difficulties and responsibilities of the work, ranging from $1,200 to $3,600 as a maximum, with only a very few reaching the latter figure.

In the Navy the Corps of Civil Engineers is recruited from civil life, but its members are commission officers with a fixed tenure of office and in all respects they are more fortunately situated than the civilian assistant engineer in the Army.

In order to answer our correspondent's question in more detail we referred his inquiry to the Bureau of Yards and Docks, and have been honored with the following reply from Admiral Mordecai T. Endicott, M. Am. Soc. C. E., Chief of the Bureau:

Sir: Replying to your inquiry of April 2, you are informed that civil engineers in the Navy are commissioned officers ranging in rank from captain to lieutenant, junior grade, in the grade of full civil engineer, and from lieutenant, junior grade, to ensign, in the grade of assistant civil engineer. When a civil engineer is chief of the Bureau of Yards and Docks he has the rank, pay, and allowances of a rear admiral in the navy.

2. The pay of a full civil engineer begins at $2,700 per year; after five years' service it is increased to $3,000 per year, and after ten years' service to $3,500 per year. The pay of an assistant civil engineer begins at $1,800 per year, and after five years' service it becomes $2,100 per year. The above is active duty pay, which is decreased when the officer is on leave or waiting orders. The pay of civil engineers depends on length of service only and not on rank.

3. Civil engineers serve at navy yards and naval stations, and their duties comprise the designing, construction, and supervision of dry docks, wharves, piers, buildings, water-works, sewerage systems, pavements, yard railway systems, quay walls, dredging, and other constructions that would naturally come under the supervision of a civil engineer in civil life. Such military duty as may be required from staff officers may also be required of civil engineers.

4. There are two vacancies in the grade of full civil engineer, to fill which a competitive examination will be held at the New York Navy Yard, beginning June 8 next. These examinations are both theoretical and practical and cover a wide range of subjects, corresponding to the varied duties of the naval civil engineer. The printed circular enclosed shows the requirements of candidates of last July.

5. The grade of assistant civil engineer has just been created by legislative action and provides for twelve such assistants. They will ordinarily work under the direction of a full civil engineer, but as their experience increases and exigencies occur may be placed in independent charge of engineering work. The appointments to this grade may be made at the rate of three a year, and a competitive examination will be held at the same time and place as mentioned above, for three for the present year. Assistant civil engineers will be taken from younger men who have more recently graduated from technical schools, as the circular to be issued in a few days will show. The examination will give the most prominence to theoretical and academic subjects, and much less will be expected of a practical nature, while at the same time the examination will be so framed as to secure men who will successfully develop into the practical naval civil engineer. After the appointment of assistant civil engineers, all vacancies in the grade of full civil engineer will be filled by promotion from the lower grade.

6. Applications for permission to take the examination for either grade of civil engineer may be made to the Secretary of the Navy at any time. These applications are placed on file and when an examination has been decided on, the applicants are notified and furnished with all the necessary information and instruction.

Very respectfully,

Mordecai T. Endicott, Chief of Bureau.

Washington, D. C., April 29, 1903.

(Since receiving the above letter, we have received the circular announcements of the examination to be held on June 8 next at the Navy Yard, New York city, for the selection of two candidates for the grade of Civil Engineer, and three for the grade of Assistant Civil Engineer. We quote from the circular as follows:

Appointees to the grade of civil engineer will enter the corps with the rank of junior lieutenant, and pay of $2,700 per annum. At the end of five years the pay will be increased to $3,000 per annum and at the end of ten years to $3,500 per annum. Appointees to the grade of assistant civil engineer will enter with the rank of junior lieutenant, and pay of $1,800 per annum, increasing to $2,100 at the end of five years. The senior civil engineer at the principal yards is usually furnished with quarters by the government.

Rank in the corps is from junior lieutenant to captain, with the chief of the bureau of yards and docks at the head, with the rank of rear admiral, and pay and allowances amounting to $6,200 per annum. Officers of the corps on arriving at the age of 62, or if disabled in the line of duty, are retired on three-fourths full-duty pay. The corps at present numbers 26 members. The last Congress authorized an increase to 40, comprising 28 civil engineers and 12 assistant civil engineers.

Candidates for these examinations must be American citizens and graduates from the civil engineering course of some professional institution of good repute. They must undergo a satisfactory physical examination. Candidates for appointment as full civil engineers must be between 28 and 35 years of age and have had at least five years' practical experience and three years in responsible charge of work. Candidates for the lower grade must be between 23 and 28 years of age, and must have had at least two years' practical experience. Circulars giving full information may be obtained by addressing the Navy Department.—Ed.)

Colonel Yorke's Report on Railway Signal Practice in America.

Sir: Referring to the recently published report of Lieutenant Colonel H. A. Yorke, R. E., Chief Inspecting Officer of Railways of the Board of Trade of England, dated Dec. 6, 1902, and more particularly to that portion bearing on automatic signals, Colonel Yorke says:

It must be borne in mind that a fundamental difference exists between manual signals and automatic signals, in that the former have human agency and human intelligence behind them and convey a direct order to a driver as to what he is to do, whereas the latter merely tell him the line is clear for a short distance ahead.

This is obviously an inaccurate comparison. A visual signal conveys its meaning and significance by form, position or color, or all of these combined. It certainly does not interest the locomotive driver to know what power is used or the kind of mechanism involved in operating the signal, because he takes his orders from the position of the signal by day and its color by night, and its indication authorizes him to advance, proceed under control, or stop. The locomotive driver does not feel any special sense of security because he may happen to know that the signal is manipulated by human agency, for he knows from everyday experience that this agency is not infallible.

Many accidents have occurred in England through the mistake of the signalman admitting two trains into the section at the same time, and unless the human agency is supplemented by some device which protects it against its involuntary acts or errors of judgment, the liability of giving false indications with the manual system of block signaling will continue.

The automatic block system gives the same direct order to the driver as does the manually-operated signal, and experience has demonstrated that this order is given by the automatic system with greater accuracy than by any human agency. We must admit that it is not at all probable that any system of signaling will be perfect in its operation at all times. Admitting this, we should select the system which gives the greatest measure of safety. The operation of the automatic system of block signaling in the United States has demonstrated to the satisfaction of the majority, if not all, of the operating officials of railways, that the automatic system of block signaling as now designed and installed is much less likely to fail than any system of signaling operated by human agency, even though it be supplemented with the continuous track circuit, which adjunct is not provided in England.

Colonel Yorke has certainly not specified the full scope and value of the automatic block-signal system when he says: "Whereas the latter 'automatic signals' merely tell him, the 'engine driver,' the line is clear for a short distance ahead."

In all complete installations of automatic block signals the locomotive driver has definite information concerning the condition of two full block sections in advance.

From paragraph 2, page 6, of the report, we quote as follows:

Goods trains of great length are now coming into use, and they are not infrequently as much as 800 yds. long. With trains of such dimensions the intervals of space between two trains may, if block signals are only 1,000 yds. long, be as small as 200 yds., which, except at very low speeds, cannot be regarded as adequate.

It is indeed a surprise to us to know that the length of a train has anything to do with the protection offered by automatic block signals be they spaced ever so close, because the automatic block section is not clear until the last pair of wheels in the train has passed out of the section; and if such a train covered two or ten blocks, it would be as fully protected from the rear as if it contained but a locomotive and brake van. If we followed the reasoning of Colonel Yorke, we might have trains overlapping each other.

The average length of block sections for automatic signaling in the United States as stated in this report is 1,000 yds., and it is further stated that "the only reason I have been able to discover for the introduction of such short block sections is that track circuits do not work well on sections of greater length."

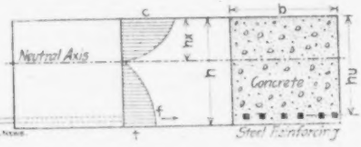


Fig. 2. Diagram Illustrating Analysis of Concrete-Steel Beams.

We believe that a closer study of the actual conditions would have shown Colonel Yorke that the length of block sections is determined solely by the business of the railway instead of the limitations of the track circuit as set forth by him, and if he but took the trouble to inspect the first and only installation of automatic block signals between Andover Junction and Grately on the London & Southwestern Ry., he would have discovered that the block sections on that line were a mile in length. This system of automatic signals was inspected by the officers of the Board of Trade, accepted by them and brought formally into use on April 20, 1902, and so satisfactory has it been that the directory of the London & Southwestern Ry. have been pleased to contract for the installing of this system between Woking and Basingstoke, a distance of 23 miles, and other companies in England are preparing for similar installations. It seems, therefore, that it is not necessary to leave England to study and appreciate the value of the automatic block system; and if it is desired to space the automatic signals farther than a mile there is at least one signal company in England, the British Pneumatic Railway Signal Co., which will guarantee to space the blocks to accommodate the business, be they more or less than a mile apart.

The failures in the automatic signal are so infrequent that the locomotive driver is enabled to carry his train at high speed with confidence, whereas in the case of the manual system, he has no such feeling of security or assurance that the position of the distant signal indicates the condition of two blocks in advance.

Colonel Yorke seems to feel that on account of climatic conditions in England there is a difference between the significance of automatic signals and manually operated signals, and that therefore there would be much difficulty experienced in "fogging."

Since the general practice in England is to provide separate apparatus for handling detonators, the necessity of providing fogmen is not more apparent in the automatic system than in the manual.

Climatic conditions in England are entirely more favorable to the operation of track circuits than is the climate in the United States, and since automatic signals have operated successfully in the United States for at least 15 years, we should have no fear of their failure to operate in England.

The satisfactory control of the movement of trains by the automatic block system has long since passed the experimental stage, and there is, in fact, no condition of climate or traffic that this system cannot meet more satisfactorily than any known system of signals operated by human agency. If the testimony of the foremost railway officials of the United States who have had experience with all forms of block signaling is of any value, we must concede the superiority of the automatic block system, because this is the system which takes first rank in the estimation of these officials and has the approval of the American Railway Association, a society composed of the highest officials of the railways of the United States. I do not know of any contemplated installation of the manual system of complete block signaling in the United States, whereas there are many hundred miles of automatic block signals under contract.

Yours faithfully,
Charles Hansel, M. Am. Soc. C. E.
Broad Exchange Building, New York city.

Diagram for Obtaining Percentage of Steel and Moment of Resistance of Reinforced Concrete Beams.

Sir: Referring to your recent discussion on concrete-steel beams, I enclose a print showing a graphical illustration of the analysis by Professor Hatt which appeared in Engineering News July 17, 1902. This diagram has been in use in my office for some time, any may be of interest to some of your readers.

With the aid of this diagram, the percentage of steel required is obtained, at once, for any given moment of resistance, when the width and depth of the beam are fixed; and vice versa, the moment of resistance of any beam can be obtained from the diagram in terms of the width and depth of the beam.

It will be seen that the moments of resistance are given for what Professor Hatt calls point "A," or when load-deflection curve first departs from a straight line, and also when the crack on the tension face of the beam eliminates the tension on the concrete, and the elastic limit of the steel has been reached. The latter condition Professor Hatt properly calls the ultimate strength in which the value of the steel is assumed at 36,000 lbs. per sq. in. With the aid of this diagram the designer can proportion a beam with any desired factor of safety between the point "A" and the elastic limit of the steel.

The diagram shows that when the percentage of steel falls below 0.3% that the elastic limit of the steel is almost reached at point "A," so that the amount of steel used should never be less than 0.3%. The diagram also shows that when the percentage of steel exceeds 2%, the compression on the concrete is 2,925 lbs. per sq. in., which is about the limit for 1:2:4 concrete at the age of six months, so that the amount of steel used should not be more than 2% for this mixture of concrete. It follows that where the percentage of steel is between 0.3% and 2% the proportion of cement can be reduced directly with the amount of steel omitted. It should be remembered that the foregoing restrictions only apply to steel having an elastic limit of about 36,000 lbs. For the higher steels the percentage to be used can be considerably less than 0.3%. For example, in cinder concrete reinforced with steel wire having an elastic limit of 80,000 lbs., the lower limit may be as low as 0.1%. In using the diagram the designer must bear in mind that the value of u, which locates the position of the steel, is fixed at 0.97. This value was found to be the best to meet the requirements for which the diagram was prepared, and applies especially to deep beams. For any other value of u, which may be

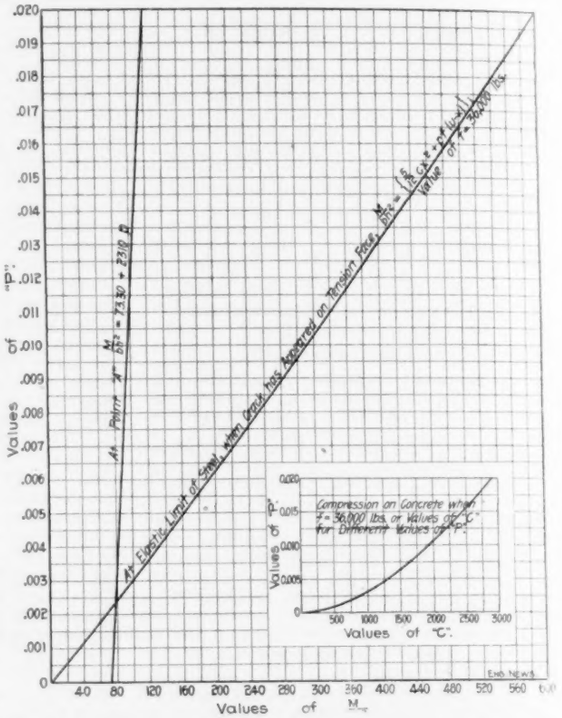

Values of "p"
Values of "M"
At Point "A" M = 73.30 + 2310 p
At Elastic Limit of Steel when Crack has Appeared on Tension Face
Compression on Concrete when f = 36,000 lbs. or Values of "c" for Different Values of "p"
Values of "c".

FIG. 1. DIAGRAM FOR OBTAINING PERCENTAGE OF STEEL AND MOMENT OF RESISTANCE OF CONCRETE-STEEL BEAMS.

h x = distance from compression face to neutral axis.
h u = distance from compression face to center of bars.
"p" = ratio of area of bars to cross-section of beam.
E_s = modulus of elasticity of steel bars.
E_c = modulus of elasticity of concrete in compression.
E_t = modulus of elasticity of concrete in tension.

$n = \frac{E_s}{E_c}$, assumed = 2 at point "A."

$m = \frac{E_s}{E_t}$, assumed = 12 at point "A."

$\frac{E_s}{E_c}$, assumed = 7.5 at point when lower face shows crack

"f" = stress in bars in tension.

"c" = compression stress on outer fibers of concrete $= \frac{t\,n\,x}{1-x}$, at point "A."

$= f \times \frac{E_c}{E_s} \times \frac{x}{u-x}$ when lower face shows crack.

"t" = tension stress on outer fibers of concrete, assumed = 300 at point "A."
E_c and E_t are measured at stresses "c" and "t."
Assumed value for "u" = 0.97 for all cases.
"b" and "h" are measured in inches.
"M" = moment of resistance of section in inch pounds.

At point "A," $x = \frac{-\left\{\frac{4+3\,m\,p}{2}\right\} + \sqrt{4\,n + \frac{9}{4}m^2p^2 + p\left[u(n-1)+1\right]6\,m}}{2(n-1)}$

At point "A" $\frac{M}{b\,h^2} = t \times \left\{\frac{5}{12}(1-x)^2 + \frac{5\,n\,x^2}{12(1-x)} + p\frac{(u-x)^2}{1-x}m\right\}$.

After the lower face of beam shows a crack, the value of "t" or the tension on concrete must be estimated. We then have $\frac{2}{3}\,c\,x = p\,f$; but $\frac{f}{c} = \frac{E_s}{E_c} \times \frac{u-x}{x}$ $\therefore$ $f = c \times \frac{E_c}{E_s} \times \frac{u-x}{x}$; (1).

or $\frac{2}{3}x^2 = p \times \frac{E_s}{E_c}(u-x)$, in which $\frac{E_s}{E_c} = 7.5$; then solve for "x"

and substitute in $\frac{M}{b\,h^2} = \left\{\frac{5}{12}\,c\,x^2 + p\,f(u-x)\right\}$; in which f = 36,000 at elastic limit of steel. The value of "c" is obtained from eq. (1)

When p = 0.020, and "f" = 36,000 lbs., the value of c = 2,925 lbs.
When p = 0.001, and "f" = 36,000 lbs., the value of c = 545 lbs.

required, the same diagram applies, but the value of p and h must be made to correspond to the new value for u. For example, if the new value for u is less than that given, a portion of the bottom of the beam must be sliced off, in the analysis for finding the moment of resistance at failure, which affects the value of p and h to be assumed.

In the above analysis, the modulus of elacticity of concrete in compression was taken at 4,000,000 lbs., as given by Prof. Hatt. This agrees perfectly with the experiments made by Henby in 1900 (see Journal of Association of Engineering Societies, Sept., 1900), although contrary to the experiments made at the Watertown Arsenal, as given by Mr. Thacher. In view of the lack of further information on this subject, the results given by Prof. Hatt and Mr. Henby should stand. Yours truly,

J. W. Schaub, M. Am. Soc. C. E.

1620 Monadnock Block, Chicago.

(For the better understanding of Mr. Schaub's diagram we give on the preceding page the analysis on which it is based as it has been worked out by Mr. Schaub.

The diagram, Fig. 2, should be consulted in connection with this analysis.—Ed.)

Notes and Queries.

Regarding the Rio Grande bridge of the El Paso & Southwestern R. R., illustrated and described on p. 323 of our issue of April 9, we are informed that credit for the design of the bridge is due to Mr. Amory Coffin, M. Am. Soc. C. E., Consulting Engineer, of 33 East 17th St., New York City. The drawings and specifications for both the substructure and superstructure were prepared for the railway company by Mr. Coffin.

In the article describing "A Spraying Device for Aerating and Cooling Water," published in our issue of April 9, an error was made in crediting the invention of the device to Mr. E. A. Uehling. The nozzle was invented by Messrs. Harrison & Gjers, of Middlesbrough, England, and was improved in form so as to make it more simple and less expensive by Mr. John Dickens, of the Uehling-Steinbart Mfg. Co., of Passaic, N. J.

H. M. M., Trenton, Mo., inquires the location of the longest standard-gage railway tangent in the world. If he will turn to page 183 of our current volume, he will find the information given on the authority of Mr. E. L. Corthell, M. Am. Soc. C. E. The said longest tangent is on the Pacific Ry. of Argentine, between Junin and La Cautiva. Its length is 186 miles. The gage of the railway, however, is 5 ft. 6 ins.

In the following letter Mr. John W. Burke, of 45 Broadway, New York city, corrects an error in a recent item:

Page 313 of Engineering News for 9th inst. contains a reference to the Southern Pacific railway embankment crossing Great Salt Lake, and in that connection states that part of the Rutland-Canadian Ry. embankments crossing Lake Champlain (described by my article in Engineering News of January 15 last) failed and gave way under a freight train. This is an error. There never has been any such trouble with the Rutland-Canadian embankments, even during construction. Probably the basis of the report was a derailment on a trestle crossing the outlet of Lake Champlain, near Rouse's Point. This is not on the Rutland-Canadian. It is about 12 miles from the nearest lake embankment.

R. D. McL., Kimberly, South Africa, wants a diagram which will give rapidly the vertical sides of right-triangles for any horizontal distance up to 100 ft. correct within $^1/_{100}$-ft. [metric advocates please take notice!], and for every minute of the angle at the vertical up to 45°.

What our correspondent wants is really a "trigonometer," such as is made and sold by some of the leading instrument makers and described in treatises on surveying. We know of none of these, however, which are made to work with such accuracy as is above specified. Our correspondent had better make his own machine on a large scale, using a good-sized vertical wall. It will be evident that either a very large scale or a very high quality of workmanship is required to read so closely as our correspondent demands.

A CHAIN WITH DETACHABLE LINKS.

By F. A. Mahan.*

The accompanying illustrations show a newly invented form of chain, with detachable links, which was brought recently to my attention. It is the invention of a former chief of piece of the French artillery, M. Bouvier. Having to put into position some guns of a certain caliber, the inventor saw the chains used in the operation break several times. As the chains had always to be carried to the shop for repairs, he was led to work out a form of chain in which a broken link could be replaced at once, and with the least practicable difficulty.

The chain is made up of two kinds of links which follow each other alternately. The first, called by the inventor the male link, Figs. 1 and 2, is a solid bar having near each end a cross arm, and on each side, between the arms, two cams whose convexities are turned toward each other. The second, called the female, Figs. 3 and 4, has at each end a double hook in which the cross arms of the male link engage, and between which the male link works. The cams on the male link prevent the cross arms from being thrown out of the hooks, except when the male link is placed in one certain position. Fig. 5 shows a female link with a male link attached at each end. Fig. 6 shows the male link arranged to carry a bucket, as for a ladder dredge or an elevator. The extremities of the cross arms extend a little beyond the outside faces of the hooks of the female link.

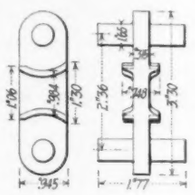


Fig. 1. Details of Male Link for Detachable Link Chain.

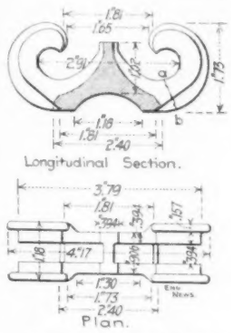


Fig. 3. Details of Female Link for Detachable Link Chain.

The wheel which drives the chain, or the sheave in which the latter runs, is made of two steel plates, assembled by means of bolts and sleeves, and working one on each side of the female links. Notches of proper shape, cut in the circumferences of these plates, take the projecting ends of the cross arms of the male link. The distance between the centers of the hooks at the ends of the female link is exactly the same as the distance between the axes of the arms of the male link. This disposition places all the projecting ends of the arms at a uniform distance apart, and consequently gives a uniform spacing for the notches on the circumference of the driving wheel, or of the sheave.

There is very little space between the hooks of the female link and the plates of the driving wheel on the outside, and the body of the male link on the other. This brings a shearing strain alone on the cross arms.

Tests of a section of this chain were made at the Royal Mechanico-Technical Laboratory at Charlottenburg, near Berlin. The specimen presented was made of cast steel. The body of the male link was 3.31 ins. long over all, 0.945-in. wide, and 0.315-in. thick. The cross arms were 0.472-in. in diameter, and projected out 0.744-in. on each side of the body. The arms were 2.36 ins. apart c. to c. The shape of the female link is so irregular that it is impracticable in mere figures to give a fair idea of its appearance. Its length over all was 4.173 ins., its width was 1.181 ins., and the maximum thickness of solid metal was 0.906-in. Sixteen links of this chain, eight male and eight female, weighed 9.295 lbs., or 1.162 lbs. for two links, one male and one female. This chain broke at 7,610 lbs., along the line a b (Fig. 3). The tests at Charlottenburg developed certain defects in form and distribution of material. The inventor is having these questions studied by a competent engineer, who has found that, without increasing the weight of the chain, the metal in each link, and especially the female, can be so placed as to give nearly one-fourth greater strength. With links of forged steel far better results can be obtained. As it is, the official tests made at Charlottenburg show that this chain, named Excelsior by its inventor, has as great resistance to rupture as that of any chain with detachable links known in France, and that, too, with about half the weight of the other chains take two links by two links. The breaking resistance of the other chains is that claimed by their maker, while the Excelsior's is that given by the official test.

The male link cannot leave its place without turning through an angle of about 135°, when the chain is laid straight, around one of its cross arms. No lateral motion can be applied to release the male link. The chain works equally well in either direction, as the ends of the links in each class are exactly alike. A small working model, made of links of the same size as those tested at Charlottenburg, and having buckets of about 5 quarts capacity attached to the male links, indicates that the chain is much less noisy than other chains in use having detachable links.

Should any of your readers desire further information on this subject, I shall be glad to furnish it. The invention has been patented in several countries. The inventor will be glad to sell the rights, preferably all of them in a block, or, if he cannot arrange this, he will sell the rights separately for the different countries.

*Major of Engineers, U. S. A., Retired. Consulting Engineer, 51 Avenue Montaigne, Paris, France.

SETTLING BASINS AND FILTER BEDS have been contracted for by the American Strawboard Co. at Anderson, Ind., to treat the refuse from its plant. It is reported that the work will cost $10,000. The plant has been made necessary by the action of farmers along the stream, which receives the refuse.

NOTES FROM THE ENGINEERING SCHOOLS.

UNIVERSITY OF MICHIGAN.—Prof. Filibert Roth, formerly chief of the Division of Forest Reserves, Dept. of the Interior, has been selected to fill the chair of Forestry in the University. With the assistance of Mr. C. A. Davis, Prof. Roth will give a regular course in foresty, beginning with the next college year. As planned at present, it will be a two-year, post-graduate course, leading to the degree of Master of Science of Forestry.

BROWN UNIVERSITY.—The new Engineering Building being erected for the immediate use of the departments of Mechanical Engineering and Drawing, will be ready for occupancy next Sep-

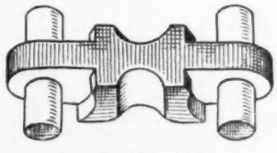


Fig 2. Male Link.

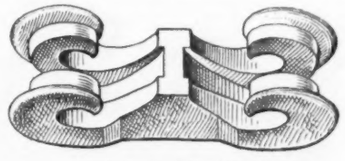


Fig. 4. Female Link.

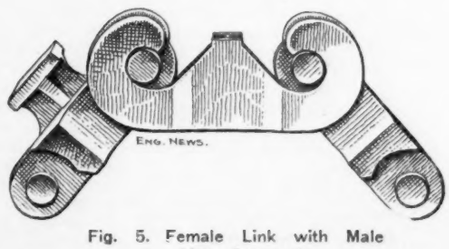


Fig. 5. Female Link with Male Links Attached.

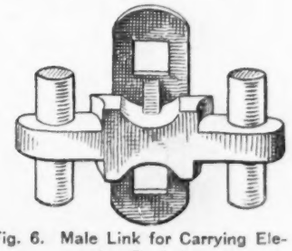


Fig. 6. Male Link for Carrying Elevator Buckets.

FIGS. 2, 4, 5 AND 6. SKETCHES SHOWING FORMS OF LINKS FOR DETACHABLE LINK CHAIN.

tember. The building is 72 × 84 ft., three stories high, and is designed so that a later addition of nearly equal size may be made to provide room for all the engineering departments. The basement, which is entirely above the ground, is 15 ft. high, and will be used as an engineering laboratory. This will contain the necessary machines and apparatus for experimental work in steam, pneumatic, hydraulic and gas engineering, and in strength of materials. On the second floor will be four large recitation rooms, a laboratory containing the lighter experimental apparatus, a dark room, a research laboratory and a library. The third floor will be used entirely for drafting.

UNIVERSITY OF CALIFORNIA.—A permanent forest experiment station has been established at the University by the U. S. Dept. of Agriculture. Dr. W. K. Hatt has gone from Washington to organize the station.

WHAT HAS BEEN DONE TOWARDS UNIFORM ACCOUNTS FOR STREET RAILWAY, ELECTRIC AND GAS LIGHTING, AND WATER-WORKS SYSTEMS.*

By M. N. Baker.†

Uniform accounting systems have been adopted by national organizations devoted to the gas lighting, electric lighting and street railway interests of the country. A uniform summary of statistics for the reports of water-works is in use by some municipal water departments. The latter covers physical as well as financial statistics, but does no more in the way of accounting than to suggest a uniform system. The outline for water-works statistics was adopted by the New England Water-Works Association, in June, 1885, thus making that organization a pioneer in the movement for uniform municipal statistics. The schedule has recently been endorsed by the American Water-Works Association, the Central States Water-Works Association, and the American Society of Municipal Improvements. Copies of it may be obtained from Mr. Charles W. Sherman, editor "Journal New England Water-Works Association," 1 Ashburton Place, Boston, Mass. It may be added that the statistics made up in accordance with the schedule are tabulated and published yearly in the "Journal."

In August, 1899, as a result of co-operation between the Street Railway Accountants' Association of America, the Association of American Railway Accounting Officers, and the National Convention of (State) Railroad Commissioners, a detailed accounting system for street railways was adopted by the latter body, after having been previously approved by the other two organizations. The schedule is printed in full in the report of the Connecticut Railroad Commission for 1899, occupying 77 pages of the same. It was adopted for use by street railway companies in making up their reports to the Connecticut Railroad Commission after June 30, 1900. The commission may be addressed at Hartford, Conn.

In May, 1901, the National Electric Light Association adopted a committee report which included a uniform system of accounting for electric lighting plants, the schedules for which are included in the Proceedings of the Convention for that year. Mr. James Blake Cahoon, 35 Nassau St., New York city, is Secretary of the National Electric Light Association.

In October, 1902, the American Gas Light Association adopted the report of its committee on final accounting, which included a detailed system of accounts. Mr. Alexander Humphreys, President of Stevens Institute of Technology, Hoboken, N. J., is chairman of the last-named committee.

*A paper presented to the National Municipal League at its convention at Detroit, Mich., April 22 to 24, 1903.
†Associate Editor Engineering News, New York City.

A NEW FORM OF PNEUMATIC MOTOR HOIST.

We illustrate in the accompanying cuts a new form of pneumatic motor hoist which is being manufactured by the General Pneumatic Tool Co., of Montour Falls, N. Y., and which possesses several features of interest in its design and operation. The direct lift pneumatic hoist has been used for a long time and is familiar to nearly everyone, but the pneumatic motor hoist is of comparatively recent development and is much less familiar. It was early recognized, however, that the compactness, simplicity, lightness, and ease with which it could be installed, would give the pneumatic motor hoist a decided advantage over any other hoisting apparatus of its class, provided in other vital characteristics it could be made satisfactory; it is practically the only form of power hoist which can be suspended by a single hook and occupy a sufficiently small head room to permit its use in all places where the hand chain hoist was formerly employed. The small pneumatic motor is not of itself very efficient; the success which it will meet, therefore, in competition with other forms of motive power for hoisting must depend largely upon its excellence in other respects and also upon the efficiency of the hoisting gear to which it is attached.

In designing the hoist illustrated in the accompanying cuts one of the first problems was the selection of a suitable type of gearing, to reduce the speed of the motor and to intensify its power sufficiently to enable it to handle the maximum load. The choice of a type of gearing like the worm or differential, would have eliminated all problems, such as sustaining the load and its smooth and safe descent. Unfortunately, however, any type of gearing which will retain the load without a brake, will be inefficient. Lowering a given load liberates exactly the same amount of power as was absorbed by it while being hoisted. The hoisting mechanism will reverse and permit the load to run down, unless the measure of its friction is equal to, or in excess of, the power stored in the object lifted. If the measure of its frictional loss equals or exceeds that of the useful work done, its efficiency will not exceed 50%, and will probably be much less. As the conversion of the motive power of the steam plant to actual hoisting, by whatever means, is accomplished only by several transformations, the careful engineer will, at least, look with regret upon a loss of so much as 50% or 60% in a single one of the transformations necessary. As a matter of fact, an efficiency of 40% is all that may be reasonably looked for in the best worm or differential types of hoisting apparatus, and in any but the very best of its class it will be even less.

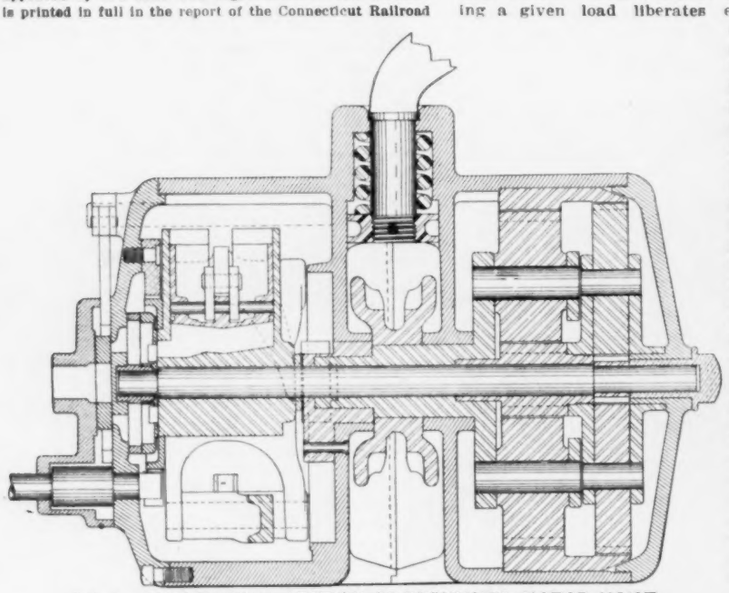


FIG. 1. LONGITUDINAL SECTION OF PNEUMATIC MOTOR HOIST.
The General Pneumatic Tool Co., Montour Falls, N. Y., Builders.

If the hoisting mechanism is, however, made up of a train of spur gearing of efficient design, an entirely new set of conditions are introduced. When power is shut off from the motor, an instant application of a brake is necessary to retain the load, and this must be partially continued while the load is being lowered, or else the motor must be capable of absorbing nearly as much power when it is running backward as it gave out in the act of hoisting. In the latter case, complete release of the brake is practicable and preferable. The substitution of spur gearing offers a perfect solution of the problem so far as securing high efficiency is concerned. The loss of power with spur gearing need never exceed 25% and may be reduced to 20% or less; combined with a high speed pneumatic motor, it corrects the only remaining difficulty, that of sustaining the load safely, and controlling it during descent.

Fig. 4. General View of Pneumatic Motor Hoist Ready for Operation.

Unlike the electric motor, the pneumatic motor is capable not only of developing power, but in equal measure of absorbing power, it may, therefore, propel the gearing while hoisting the load, or restrain the gearing while lowering the load. Its ability to fulfill the latter function, and thus avoid the complicated apparatus which would otherwise become necessary, gives to it an advantage which far outweighs its small lack of efficiency. A high speed pneumatic motor was, therefore, chosen, because of the ease and certainty with which the load could be sustained by a brake applied directly to the motor shaft; the high speed of the motor insures a high ratio of gearing between the lifting sprocket or drum, and the motor; and insures the load being sustained even with a very light application of the brake, hence with a brake of moderate power, a large margin of safety is obtained. High speed in the motor, and consequently a high ratio between the motor and load hook for hoisting apparatus, affords relatively the same advantage as the high ratio between the dial and measuring points of the micrometer; in either case an easily controlled movement of the one part, effects the greatest nicety needed for the other part. With a pneumatic motor, during the process of lowering the load, even with the supply hose disconnected, and the brake entirely inoperative, if the throttle is released, both the supply and exhaust parts will be closed, and a vacuum will be created during one stroke of the piston, and compression during the other stroke; the intensity of both the vacuum and compression will increase until the load is arrested. In practice, two or three turns of the motor only will be necessary to bring the load

to rest. Absolute safety is, therefore, offered against accident, even with the most careless operative. The throttle and brake operate in conjunction; the brake automatically grips the motor, when pressure is cut off, and at the same time the exhaust and inlet ports are closed. Either of these conditions would hold the load suspended.

The motor used is of the piston type, of simple design, consisting of three single acting cylinders radially mounted upon a hub on the driving shaft. Each cylinder carries a bell crank, to one end of which is attached the piston, to the other end a roller suited to revolve about a stationary eccentric. Air pressure acting upon the pistons successively pushes them outward, causing the rollers to bear forcibly upon the eccentric, just at the time they pass its highest point. As the rollers under load roll down the incline formed by the eccentric, they propel the cylinders forward in their circular path. Air pressure is led to, and exhausted from, the cylinders as the parts in the hub rotate alternately past the supply and exhaust openings in the cover plate of the hoist shell. Self-adjusting metallic packings are used in the pistons, and on the face of the hub, which will keep the parts perfectly air tight.

The bearings are not subject to reversal of stress, hence they do not need adjustment, and are durable and quiet running. Centrifugal stresses, which have been an objectionable feature of motors of this type, are nearly balanced between the piston at one extremity of the bell crank, and its heavy arm and the roller at the other extremity. The fast running bearings are, therefore, practically without load other than that due to the air pressure. Inertia and momentum strains are nearly eliminated, since every moving part of the motor traverses a truly circular path; it, therefore, runs without vibration, and adapts the hoist for the most exacting service. In foundry practice, for instance, the entire absence of vibration, either in the motor or gearing is found to be of great advantage. When desired, the hoist is provided with a governor valve which is controlled by the load hook, and which will supply at all times exactly the amount of air required to handle the load, resulting in a decided economy in air consumption. The spur gearing used between the motor and lifting sprocket or cable drum, is arranged in two separate trains; it is enclosed within the hoist shell, and runs in a bath of oil, under conditions the most favorable for efficiency and durability. The motor is also fully enclosed, and runs in a bath of oil; copious lubrication of every running part is therefore assured, and the attendance is reduced to an occasional replenishing of the supply of oil. No oil is ever fed to the motor with the air supply, hence none is ejected from the exhaust opening, and the supply in the motor case is only very gradually consumed. Nearly all the troubles attending the use of the air motor, have probably resulted from the difficulty of securing proper lubrication. It will suffer injury very quickly from want of oil for either its internal or external wearing surfaces. A method by which all wearing surfaces are constantly bathed with oil, without giving the lubricant direct access to the interior of the motor, where it may be carried to the exhaust opening, and thus wasted, should prevent injury to the wearing surfaces, and promote as long a life as in any other form of motor. This in connection with the methods used for packing every part subject to pressure, enables it to retain its efficiency indefinitely.

The hoists are made in two types; those using a chain running in a sprocket wheel, and those using a wire cable winding upon a drum. The distinct advantage of the chain type is the ease with which an auxiliary high speed hoist may be provided by attaching a hook to the free end of the chain; the main load hook is then attached to a lower block carried by two strands of the lifting chain, and is used for loads approaching the maximum which the hoist will handle, while the hook attached directly to the free end of the chain and running at double the speed of the block, is used for light loads up to half the capacity of the hoist. In all cases where the sprocket and chain are used, a spring chain guard is provided which effectually prevents the chain from climbing the sprockets, or any jar to the load from movement of the chain in the sprocket; because each link of the chain is firmly seated by the spring guard, before it is subjected to any load.

Referring to the illustrations: Fig. 1 is a sectional elevation longitudinally through the entire hoist, showing the motor and its controlling and reversing valve at the left, the lifting sprocket at the center, and the hoisting gearing at the right. Fig. 2 is from a photograph of the motor in position in the hoist shell, and Fig. 3 of the gearing in position in another compartment of the hoist shell. In Fig. 3, the component parts are also seen removed from the shell. Attention is called to the fact that removal and replacement of all the working parts, in either the motor or gearing compartments is practicable without in the least disturbing the adjustment, hence inspection, repair, or renewal of any worn member is possible with the least trouble or delay. Fig. 4 illustrates the hoist as seen under working conditions, and shows its compactness and symmetry of form.

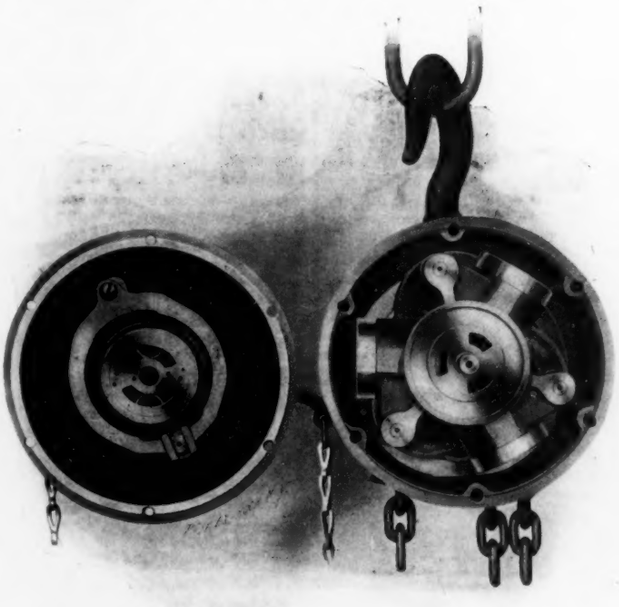


FIG. 2. INTERIOR VIEW OF PNEUMATIC MOTOR HOIST, SHOWING COMPRESSED AIR MOTOR.

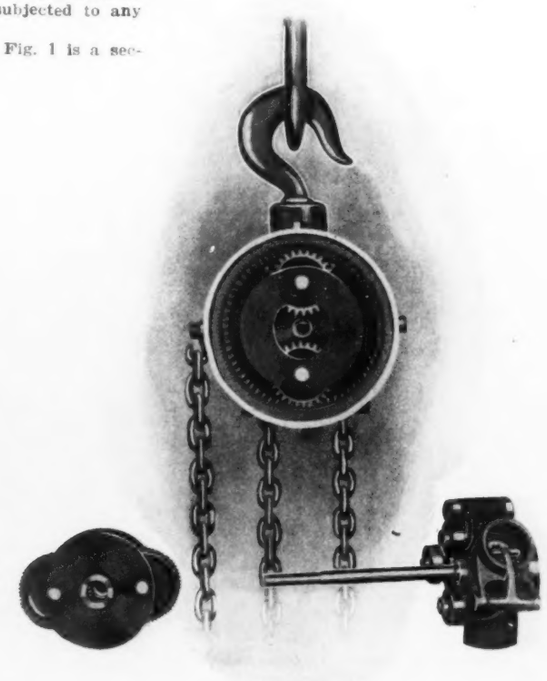


FIG. 3. VIEW OF PNEUMATIC MOTOR HOIST SHOWING OPERATING MECHANISM.

THE COST OF DIAMOND DRILL BORINGS IN THE COLORADO RIVER VALLEY AND AT ST. MARY'S LAKE, MONTANA.

By A. P. Davis.*

The reclamation service of the U. S. Geological Survey, F. H. Newell, Chief Engineer, which was organized under the provision of a law approved June 17, 1902, is engaged upon investigations of irrigation possibilities in the majority of the States and Territories of the arid region. In connection with these investigations it is, of course, necessary to make test boring at numerous locations for foundation of dams and material to be excavated in the construction of canals and tunnels. As this work is usually carried on in remote regions, some of them extremely difficult of access and varying widely in conditions encountered, some notes as to experience thereon may be of interest to your readers.

Thus far most of the boring has been done at the sites of proposed dams, where it is necessary first to sink casing to bed rock, make a tight joint therewith, and then by means of the diamond drill penetrate the rock to a sufficient depth to test its continuity and uniformity and obtain core samples.

In most cases portability of plant is the first requisite. It is seldom that wagons can be taken to the vicinity of the dam site, and often it is difficult to reach it on foot. For this reason various forms and arrangements of hand machinery have been used from time to time, and in last December a small steam outfit was installed on the Colorado River at Bull's Head, about 30 miles north of the town of Needles, on the Santa Fe Pacific R. R. The drill used is the Bullock "Beauty," furnished by the Sullivan Machinery Co., of Chicago. The casing is extra strong steel drive pipe, 2½-in., standard size.

The general investigations of the Colorado River Valley are under the charge of Mr. E. T. Perkins, M. Am. Soc. C. E., and the drilling party is under the immediate charge of Mr. John T. Whistler,

*Principal Engineer, U. S. Geological Survey, Washington, D. C.

M. Am. Soc. C. E. The following is extracted from a report by Mr. Whistler, dated February 19:

Two lines of holes across the river, 100 ft. apart, will have been completed at close of work to-day. Generally, very hard, but somewhat coarse and seamy granite has been encountered at depths of from 40 ft. to 50 ft. below river surface. The hole on Nevada end of line farthest south developed a brackish water which rose in casing to height of 3 ft. above river and flowed at 2 ft. probably 10 to 15 gallons per hour. The first hole in center of river was drilled 24 ft. in rock and showed the same character of material all the way through. The remaining holes have been carried to about 10 ft. below rock and show practically the same character, varying only in coarseness of structure.

The rock channel, as shown by borings, has very abrupt sides covered on bottom to a depth of from 26 to 40 ft. generally with sand and gravel.

On the Arizona side of lower line of holes, a mass of granite boulders of same character as bed rock, both exposed and under water, was encountered. These are probably the rock blasted off some years ago under the direction of U. S. Engineers.

The total time employed in the drilling, beginning December 20, when the first actual work of drilling was done, and including to-day, has been 45¼ working days. Of this time, I have estimated that at least seven days were consumed in experimenting with oil burners, and making changes and repairs, incident to these experiments, i. e., time lost that would not have been lost had we used wood from the beginning. Mr. Tierney estimates at least one entire day lost on account of defective firing caps, but this is probably chargeable to drilling and has not been deducted. Attention must be called also to the fact that, while we have tried to pick up for the crew men who have some knowledge of machinery, their lack of efficiency in the beginning and increasing efficiency as work has gone on, is in no way better shown than by reference to the attached condensed record as taken from boring notes. With the exception of chief driller, Mr. P. Tierney, and assistant driller, James Dopson, the crew has been composed, for the most part, of prospectors and the class of men who travel from mine to mine, and even Dopson, while an excellent man, knew absolutely nothing about the work at first. Mr. Tierney, as diamond setter and driller, is by far the best man for this class of work I have ever known. He is very conscientious, sober, industrious and extremely careful. The fact that in this most difficult kind of boring coarse granite in which quartz predominates, he has not lost or seriously injured a single carbon, shows it. The loss on carbons to date, at the most liberal estimate, cannot be more than $50—being three small chips and the wearing of one unusually soft carbon. Mr. Dopson, as assistant driller, is doing fully as well as could be expected, and Mr. Tierney already places much confidence in him.

The working hours have been from 7 a. m. to 5 p. m. with one hour noon, the fireman going up before breakfast and getting up steam.

Hole	No. 1	required	14	working days.
"	No. 2	"	7¾	" "
"	No. 3	"	10	" "
"	No. 4	"	6	" "
"	No. 5	"	3½	" "
"	No. 6	"	4	" "

Probably nearly half the time on Hole No. 1 can be charged to experimenting with oil burner, and on each of holes No. 1 and No. 2 from one to two days can be charged to new, rough casing, which turned and drove very hard in the fine sand. Hole No. 3 was unusually difficult and I think the average time for holes 5 and 6 is probably about what can be counted on, unless conditions differ considerably. Practically an entire day was lost on hole No. 6 on account of faulty chopping bit breaking in hole and defective firing caps, which failed to explode, necessitating careful chopping out of dynamite. The expense per month, exclusive of supervision, locating of holes, etc., is approximately as follows:

Salaries, 4 to 5 men	$330
Subsistence, 4 to 5 men	81
Interest at 3% on $2,800	7
Wear of machinery, including boats and repairs	46
Wear and loss of carbons	50
Fuel	35
Total	$523

At 26 working days to a month this will make $20.12 per working day to run the drill. Taking total time occupied in putting down six holes as 38¾ working days, exclusive of seven days estimated to have been lost on account of oil burners, etc., the whole cost has been $769.60. The combined depth to which holes have been put down is 340 ft., which makes the cost per foot depth $2.26. The time on last two holes on which but four men were employed, reducing cost to $19 per day, was 7¾ working days, at $19 per day makes cost $147.25. The combined depth of these two holes is 100 ft., which makes cost per foot depth $1.47. This I regard as a remarkably good showing when it is noted that of the 340 ft. total depth 79 ft. were of diamond drilling and but 55 ft. water. This estimate is for comparison and does not include transportation. . . . .

The question of fuel we have discussed fully, heretofore. The drilling record attached confirms the belief that no heavy oil can be used successfully on account of very small flame required for the greater part of time. I am of the opinion that a distillate with distillate burner would be a success; but am not prepared to make an estimate on cost. Am inclined to think that where wood can be had in this country it will be cheaper than any oil. We find that not more than twice as much wood is required without oil, as with it. We burn not over 1½ cords of mesquite wood per week. It costs us $3.24 per cord 11 miles away, and can be delivered for about $3 more.

It is interesting to compare with this the results of boring with hand machinery in other localities.

At St. Mary's Lake, in Montana, flush joint casing was sunk by the jetting process by hand labor, under charge of Cyrus C. Babb, M. Am. Soc. C. E. Diamond drill cores were taken from each hole by hand power. The work was especially difficult on account of frequent boulders encountered. The outfit of machinery, including freight and excluding carbons, cost $1,400.

The drilling expenses were $3,080, or about $1,000 per month.

The total amount of drilling accomplished, not counting holes that were abandoned on account of difficulties before completion, was 550 feet, at an average cost of $5.60 per foot, exclusive of the cost of machinery.

In 1901 drilling was done in Tonto Basin, on Salt River, Arizona, under the immediate supervision of the writer. The Pierce driving rig and American Diamond Drill Co.'s hand drill were used, and hand power employed exclusively. The period of work covered a little over two months. Exclusive of the transportation of men, and of the first cost of machinery, the cost was as follows:

Pay roll	$1,400
Subsistence and camp expenses	460
Repairs and miscellaneous	340
Total	$2,200

Total amount of drilling, not counting unfinished holes abandoned on account of accident or difficulty, 905 feet. Cost per foot, $2.43.

FAILURE OF A CONCRETE STEEL ELEVATOR AT DULUTH.

Our readers may recall the description in our issue of Dec. 27, 1900, of the failure of parts of the Peavey concrete elevator at Duluth, Minn. On April 16 a second failure occurred in this structure, the results of which are shown in the accompanying photograph. The general construction of the elevator is shown in Fig. 2. The weak point of the construction, as was explained two years ago, was the use for storage of the interior star-shaped space between the circular bins. In the accident two years ago one of these intermediate bins failed and wrecked the two adjacent circular bins. On April 16 another of the intermediate bins failed and carried with it the cir-

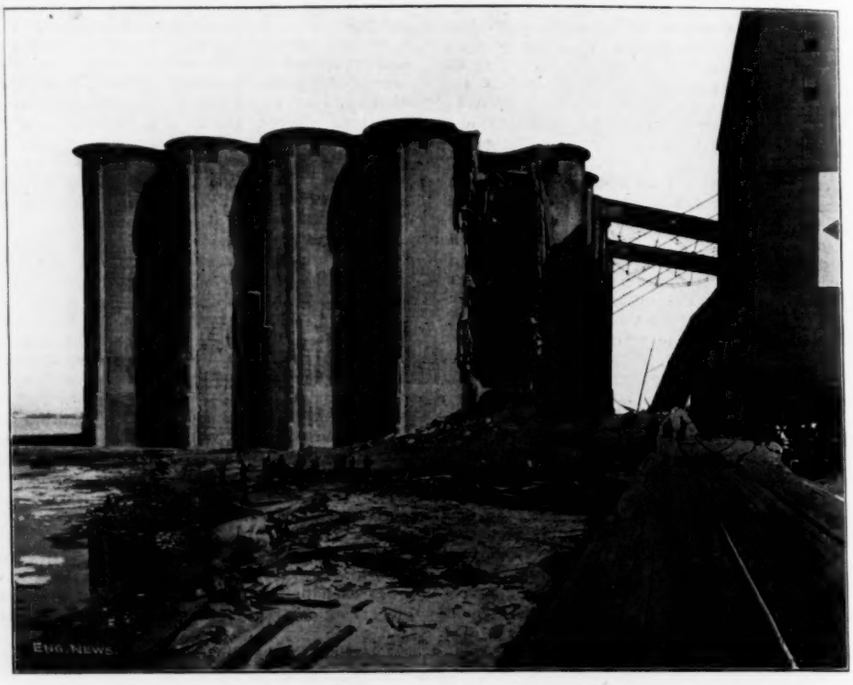


FIG. 1. FAILURE OF CONCRETE-STEEL GRAIN ELEVATOR BINS AT DULUTH, MINN.

cular bin on the southwest corner. About 75,000 bushels of flaxseed contained in the burst bins flowed out like a wave of water, actually raising the floor of the adjacent railway trestle, as shown in the photograph.

The concrete in the bins was made of beach gravel from the shores of Lake Superior. Samples of the fractured concrete showed a considerable percentage of voids and there was found considerable foreign matter, such as chips, bark, etc., gathered up with the gravel.

In the summer of 1901, following the first failure, a considerable number of bins were added to the structure and were built with thicker walls, heavier buttresses and a larger amount of embedded steel than was used in the original construction. These bins, we understand, have stood without sign of weakness.

In the original construction the bins were 33 ft. 6 ins. in diameter and were built with walls 12 ins. thick at the bottom and 9 ins. at the top

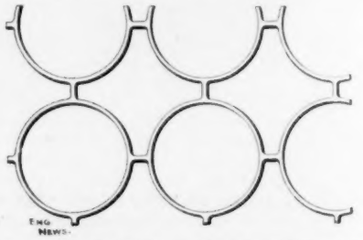


Fig. 2. Horizontal Section Showing Construction of Duluth Concrete-Steel Elevator.

The steel reinforcement was 1½ × ⅜-in. steel bands, spaced 12 ins. c. to c.

Reference to Fig. 2 will show that when the interior star-shaped bins are filled, their sides act like arches, and set up bending stresses in the short sections of wall connecting the circular bins. We are informed that the two circular bins next the one that failed on April 16 show very plain vertical cracks midway between the buttresses, running nearly the full height of the bins

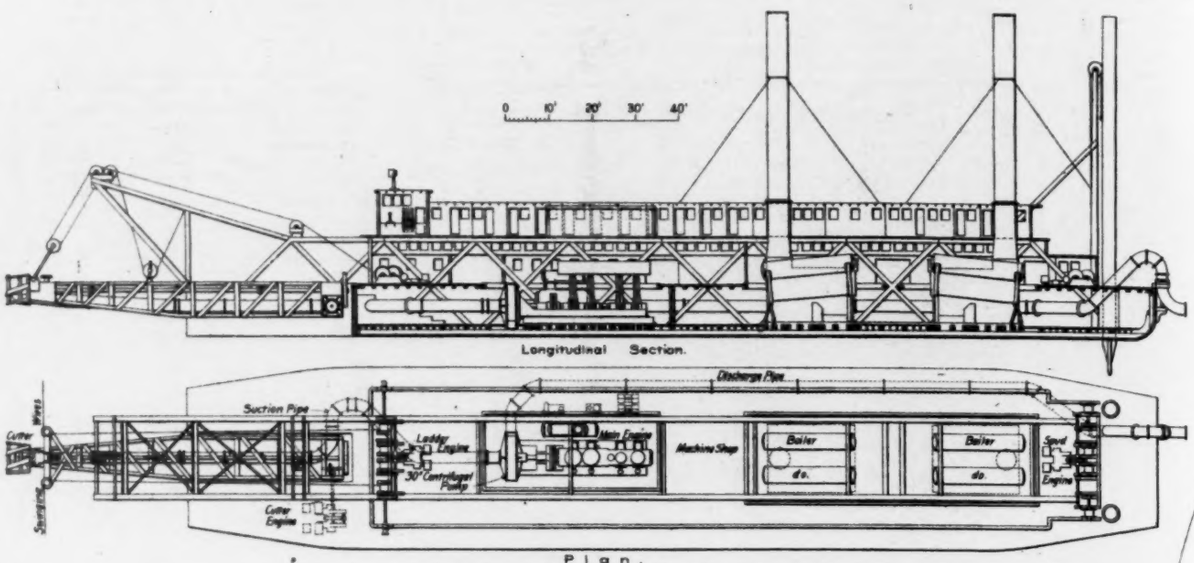


FIG. 1. PLAN AND LONGITUDINAL SECTION OF DREDGE.

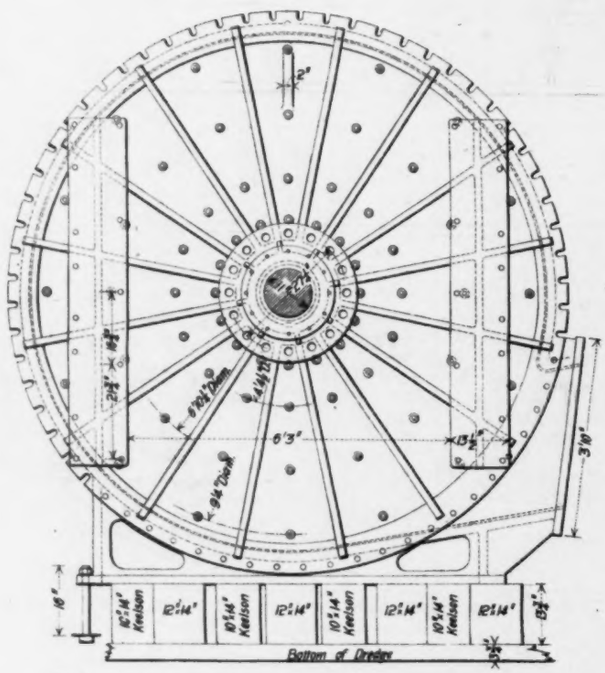


FIG. 11. RUNNER COVER OF PUMP CASING SHOWING CONNECTION TO BED PLATE SHOWN BY FIG. 10.

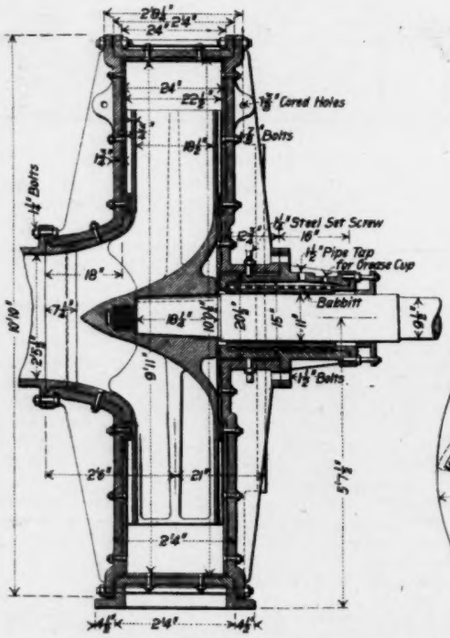


FIG. 12. VERTICAL SECTION OF 30-IN. PUMP SHOWING PARTS IN POSITION.

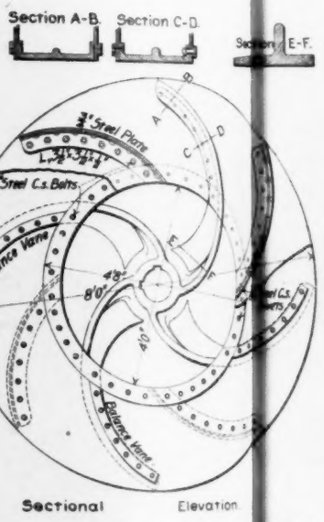


FIG. 13. DETAILS OF 8-FT. RUNNER FOR 30-IN. CENTRIFUGAL PUMP.

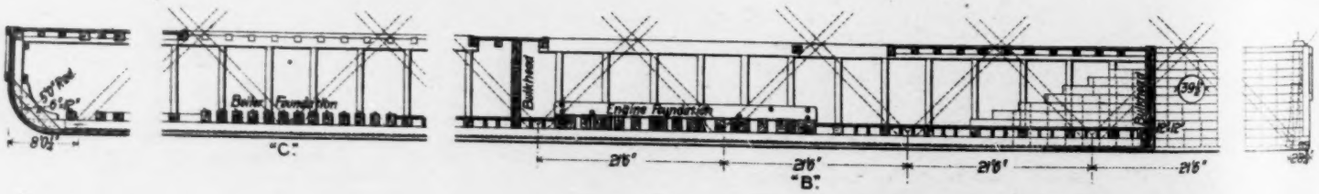


FIG. 2. DETAIL SECTIONS SHOWING HULL CONSTRUCTION.

THE 30-IN. CENTRIFUGAL SUCTION DREDGE FOR T

J. B. C. Lockwood, M. Am. Soc. C. E.

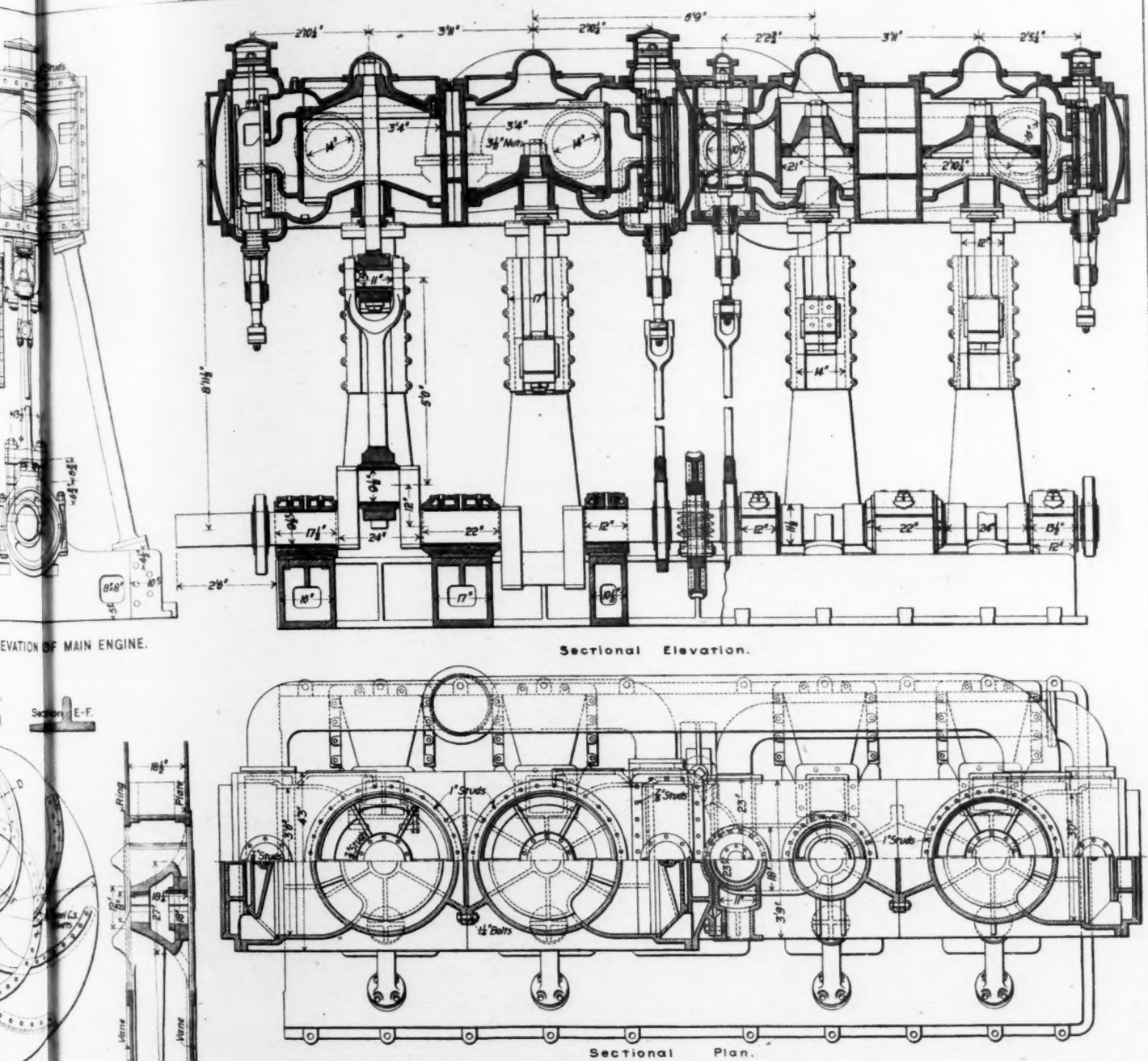
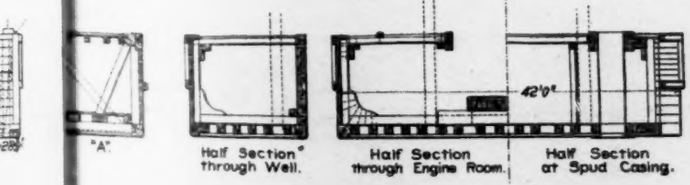


FIG. 8.
VERTICAL SECTIONAL ELEVATION
AND TOP PLAN
OF MAIN ENGINE.

EVATION OF MAIN ENGINE.

LS OF 8-FT. RUNNER
ENTRIFUGAL PUMP.



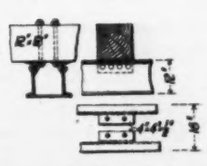


FIG. 4.
CONNECTION OF
STEEL TRUSS TO
FLOOR-BEAMS OF HULL.

DREDGE FOR THE PORT OF PORTLAND, OREGON.

M. Am. Soc. C. E., Designing Engineer.